

Sentinels of Safety: A Robotic Revolution in Autonomous Landmine Detection for Humanitarian Resilience

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Abstract

Landmine Detection Robotic Vehicle Project is to create an autonomous robotic system that can identify landmines in dangerous locations. The rover navigates through a variety of terrains by using modern sensor technology, such as metal detectors and infrared photography, to detect buried landmines. The rover can distinguish between potentially dangerous items and harmless ones. The principal aim of the project is to optimise the efficacy and security of landmine removal operations, thereby reducing human risks and increasing the worldwide efforts to completely remove landmines. By integrating advanced algorithms for sensor fusion and data analysis, the autonomous vehicle can identify and analyse suspected landmine targets in real time. In order to minimize false positives and ensure the best possible detection accuracy, machine learning approaches are utilized to improve the system's capacity to distinguish between harmless items as well as potential threats. Additionally, the vehicle has a remote monitoring and control interface that allows its operators observe activities from a safe position while still having complete control over the vehicle's actions and sensor functions. This remote capability allows for the effective deployment of resources in difficult environments while also improving the safety of people engaged in landmine detecting operations. After undergoing extensive evaluation and testing in both simulated and real-world environments, the proposed robotic vehicle exhibits positive result for safety, efficiency, and accuracy of detection. This project is to support global efforts to reduce the humanitarian impact and improve the removal of impacted regions for safe human habitation and development by utilizing the power of robots and cutting-edge sensor technology.

Keywords: Robot, landmine, rover, security, landmine detection rover, sensor technology, environment, remote region

INTRODUCTION

One innovative project aimed at solving the frequent and deadly problem of landmines in areas affected by conflicts is the Landmine Detection Robotic vehicle Project. To lower the risks involved with manual demining operations and protect civilian lives, this autonomous robotic technology is designed to effectively detects landmines. With modern sensing tools including metal detectors, the rover is able detect buried landmines with high accuracy. With the help of its autonomous navigation system, it can navigate difficult terrains like uneven and rocky surfaces, assuring that the directed areas are fully covered. The project includes a safe and controlled way for disposing of landmines that have been identified in addition to its detection focus. The rover can securely identify landmines without the need for human assistance. This project introduces an intelligent and practical

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approach to mitigating the dangers associated with landmines by leveraging the capabilities of modern technology. Landmines, often deployed in conflict zones or border regions, remain hidden beneath the earth's surface long after the cessation of hostilities. These hidden explosives continue to claim lives and maim individuals, disproportionately affecting civilians, including children and farmers. Furthermore, they hinder agricultural activities and impede the growth of infrastructure, thereby perpetuating cycles of poverty and underdevelopment. This project centres on the development of a robotic system designed to autonomously detect landmines with a high degree of precision and safety. By integrating a Raspberry Pi 3A single-board computer, an L298 motor driver, 12V DC motors, a GPS locator, and a metal detector sensor, the robot combines the power of computing, mobility, and sensor technology to create a versatile and efficient solution for landmine detection. The Raspberry Pi 3A serves as the project's central processing unit, orchestrating the robot's movements and the analysis of data from integrated sensors. The L298 motor driver and 12V DC motors equip the robot with the capability to navigate challenging terrains, ensuring it can access even the most remote or hostile areas safely [1].

Crucially, the GPS locator enables accurate geospatial data collection, providing essential coordinates for detected landmines. This information facilitates immediate deactivation and contributes to the creation of detailed maps, which are invaluable for future minefield clearance efforts. The project's core innovation is the inclusion of a metal detector sensor, a primary component for landmine detection. This sensor can identify metallic objects concealed below the ground, such as landmines. When the sensor detects a metal object, the robot can promptly respond by marking the location for later removal or steering clear of the potentially hazardous area [2]. This project represents a commitment to addressing a global humanitarian crisis by employing cutting-edge technology to reduce the risks associated with landmines. It offers real-time detection capabilities, remote operation, data logging and mapping, and expandability for future enhancements.

LITERATURE SURVEY

The unmanned ground vehicle was selected as the ideal platform for this project due to its stability and ability to operate for extended periods of time.

Abhishek K. Jadhav et. al. [3] A device designed to identify explosive, and landmines buried during wars. The system consists of several parts, including an inbuilt camera, a GPS module for real time position data, a metal sensor to identify landmine, and a Raspberry pi module for live video streaming. The Landmine Detection Robot (LMDR) is controlled by a specifically built website that sounds an alarm when a landmine is found. The service also offers position monitoring and live video streaming, enabling the robot to be navigated remotely. The primary benefit of the system is its web-based control, which allows for operation across any distance and make it possible to cover bigger regions without physical constraints.

Deepak Kumar Tripathi et. al. [4] Enhancement in scaling mountains rovers and landmine detecting. It looks into methods for locating hidden landmines, such as metal detecting and ground-detecting radar, as well as the use of drones and robots for their secure removal. The difficulties of finding mines in difficult terrain are discussed, with a focus on convenient solution. These include choosing inexpensive metal detectors for autonomous ground vehicles and adding GPS trackers. The goal of the article is to present a thorough examination of existing technology, with a focus on novel ways to improve efficiency and safety in the detection and disposal of landmines as well as the many uses for rovers that can climb mountains.

Nandakumar K. et. al. [5] The workings of an automated vehicle with wheels that can move and a metal detector on the front. The vehicle stops and uses the Blynk app to send its GPS coordinates to a smartphone when the metal detector detects a landmine. Wi-Fi networking is made easier and transmission to the Blynk app is coordinated by the ESP8266. The control station and the actual robotic vehicle are the two parts that make up the robotic vehicle. The control station functions as a single, integrated system that combines GPS data gathering, metal detection, and remote-control components. Even though they are integrated, these parts work independently and concurrently.

Rahul Bansode et. al. [6] An Internet of Things (IoT)-based landmine detecting robot is presented that integrates wireless connectivity, data processing algorithms, sensor technologies, and autonomous navigation capabilities. The IoT-based landmine detecting robot locates landmines efficiently by fusing robotic skills with the power of IoT technology. By lowering the hazards associated with manual demining operations and improving the speed and accuracy of landmine identification, this breakthrough has the potential to save countless lives.

Since they are difficult to detect and have unknown positions, landmines are a major threat. Combining sensors can lead to a more precise landmine detection. The incorporation of GPS technology makes it possible to remotely send the specific position of landmines that have been discovered, allowing for the safe disposal of the explosives. via making use of open-source software and a Raspberry Pi microcontroller. We can create a rover that is both inexpensive and configurable thanks to the mentioned articles.

PRESENT METHODOLOGY

The control of the land mine detector rover is the initial step in its operation. Because this robot is built on a Node MCU and Raspberry Pi, it can be controlled online. A dedicated web page with buttons to control the robot's forward, backward, and left-and-right motions has been created specifically for this purpose. robot's wheels for moving the vehicle around the terrain in both clockwise and anticlockwise directions. The robotic vehicle has a metal detector installed on its front side that can detect mines ahead of it. When the robotic vehicle detects a landmine, it stops at that location and uses the GPS module to relay the coordinates to a mobile device [7, 8]. the coordinates of a specific landmine location, which are then transferred to the Blynk app on the controlling end. The ESP8266 can be used to launch an application or to delegate all Wi-Fi networking tasks to other applications. which uses internet access to obtain the latitude and longitude location and provides it to the Blynk app. The webpage furthermore features a camera output window that streams live footage from the robot's camera. Additionally, it has an LED indicator to show whether a landmine is nearby. The red indicator LED on the rover will light up to indicate the presence of a landmine right away as the robot's detector of metal finds one. The website transmits data to the cloud when the controlling person touches any of the control buttons. The SD card is loaded with all the code required to operate the robot, and the Raspberry Pi is then fitted with it.

Hardware Components

- *Raspberry Pi 3A*: The robot's primary command unit is the Raspberry Pi. It manages the robot's movements, processes data from sensors, and communicates with the user or operator.
- The robot can move thanks to the L298 Motor Driver and the 12V DC Motors. The robot can traverse a variety of terrains thanks to the L298 motor driver, which regulates the motors.[9]
- *GPS Locator*: The GPS locator provides accurate geospatial data, allowing the robot to determine its location and record coordinates. The main element involved in detecting landmines is the metal detector sensor as shown in Figure 1. It can recognise metallic items buried in the earth, including landmines.

Control and Software

- *Programming*: The movements of the robot and the processing of information collected from sensors are managed by the Raspberry Pi.
- Custom software is developed to manage the robot's operation, enabling it to respond to sensor data and navigate autonomously.
- *Data processing*: The software processes data from the GPS locator and the metal detector sensor. It uses the GPS data for mapping and coordinates, while the metal detector sensor data is analysed for metal object detection.
- *Safety protocols*: The software includes safety protocols to ensure that the robot operates in a safe and controlled manner, especially in areas with suspected landmines.

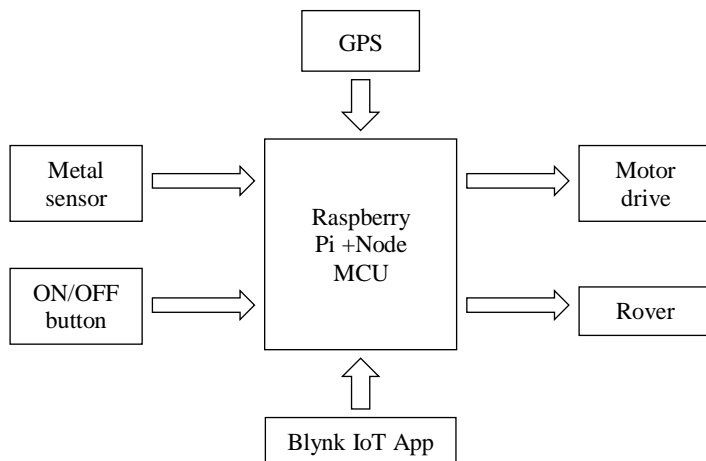


Figure 1. Block Diagram of landmine detection robotic vehicle.

RESULTS AND DISCUSSION

This idea has successfully demonstrated that land mines can be located remotely by human interaction. This will allow for the exploration of a new sector in the study of military defensive equipment [10–13]. Additionally, since the robot has already traversed the route that the soldiers are taking, there is no longer any chance of a landmine for the soldiers, ensuring their complete safety. The system's biggest benefit is safety because it will save troops' lives, which is crucial for the security of any country. The robot is made to be able to move in the following four directions: front, back, left, and right.

Its functionality extends to detecting mines ahead of its path, making it an asset for mine detection missions. This model is cost-effective due to its simplified structure, which not only reduces production costs but also simplifies maintenance. Its simplicity makes it easy to build, ensuring accessibility for various applications requiring landmine detection. Moreover, the robot's ability to provide precise coordinates of detected landmines via a GSM module enhances its effectiveness and utility in safeguarding against potential threats. Rover of the proposed system is presented in Figure 2.

At a starting position, the robotic gadget will be deployed onto the field. Now that the programming has been completed, the device will travel autonomously across the field, and the Raspberry Pi will notify the monitoring system of its location if it detects any metal objects. Also, because an ultrasonic sensor is used for obstacle avoidance, impediments won't interfere with how it operates. The precise position of the landmine at the monitoring system will be plotted using all the measurements that have been collected. There is no need for people to run this robot because it operates autonomously. Following the completion of the detecting process, the machine will return to its initial position. In addition to saving lives, this will shorten the time needed for discovery.



Figure 2. Rover for landmine detection.

Real-time interaction: Using the Blynk app, users can communicate with the rover in real-time by giving orders and getting responses right away. This makes it possible to effortlessly monitor and manage the rover's location and status from a distance.

All things considered, Blynk offers an easy-to-use interface for managing Internet of Things devices as shown in Figure 3, such as the rover for detecting landmines, making it possible to operate remotely and visualize data.

Reliable geographic information is essential for efficient demining activities. This was one area where our robot excelled, accurately capturing GPS information. The precise maps of the test regions made possible by the data logged throughout the studies made it easier to identify and remove landmines that were found as shown in Figure 4. This skill enhances the efficacy and safety of humanitarian demining operations.

Using its inbuilt sensors, the rover quickly captures the exact coordinates of any landmines it comes across. Users may see the precise position of the discovered landmine on a virtual map thanks to the real-time transmission of these coordinates to the Blynk app. Users can determine the precise position of the discovered landmine and take the necessary action by obtaining the coordinates supplied by the rover.

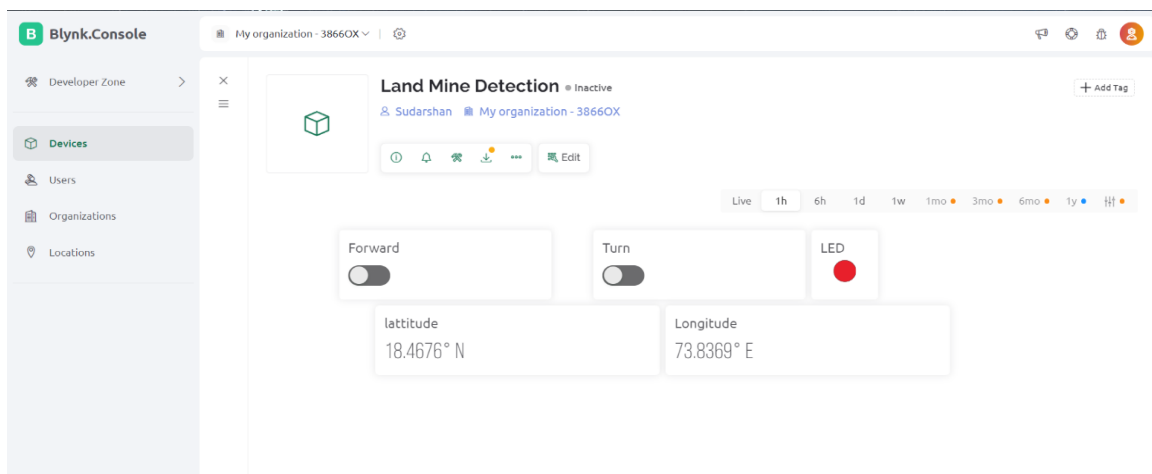


Figure 3. Blynk IoT Interface.

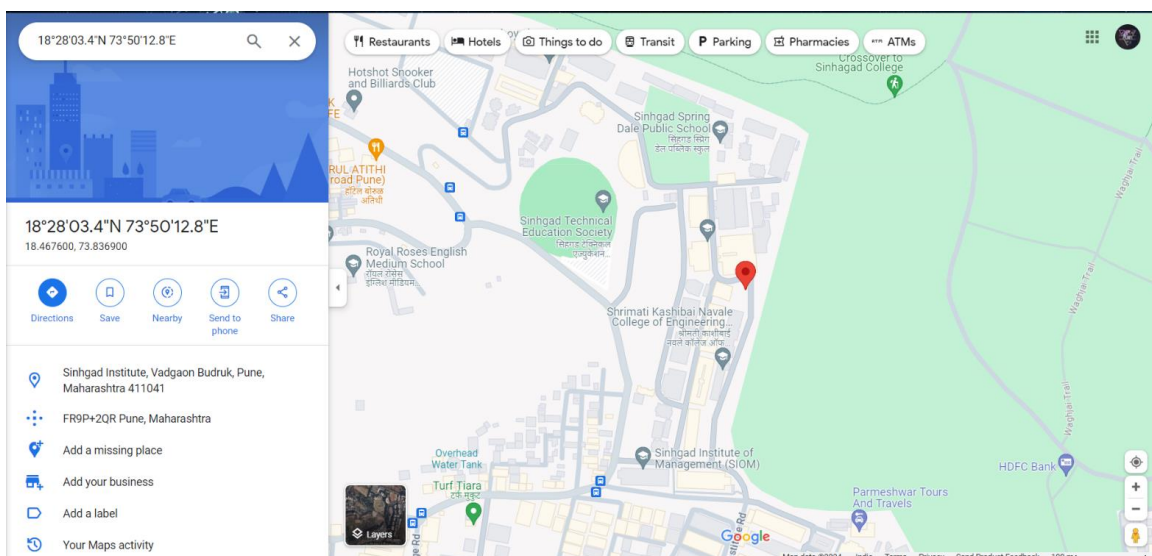


Figure 4. Detected location.

CONCLUSION

In solving the critical issue of landmines, the Landmine Detection Robotic Vehicle Project is an essential step forward. With its modern sensing technologies, safely detection procedures, and autonomous capabilities, the rover has the capacity to improve detection operations, increasing their accuracy, efficiency, and above all reducing the hazards to human life. This project has the potential to make an important contribution to the worldwide objective of establishing safer settings in conflict-affected countries, ultimately saving lives and promoting post-conflict rehabilitation, by fusing innovation with a social focus. One major step toward solving the pressing problem of landmines is the Landmine Detection Robotic Vehicle Project. To improve landmine detection operations, this creative initiative combines state-of-the-art sensor technology, secure detection protocols, and autonomous capabilities. The rover's ability to precisely traverse across dangerous terrain enhances the precision and effectiveness of detecting techniques. The initiative significantly reduces the risk to human life by lowering the dependence on human deminers.

The Landmine Detection Robotic Vehicle Project is in line with the worldwide objective of establishing safer surroundings in conflict-affected areas. By taking out the threat posed by landmines, the initiative helps displaced people to return home, encourages agricultural regeneration, and makes infrastructure reconstruction possible. The project's emphasis on social effect and innovation has the potential to save a great deal of lives and quicken the process of healing after a war.

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