SAFE PATH DETECTION ROBOT

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Abstract— The world is changing day by day the technologies are also evolving. Various technological changes have been adapting to the military application. On the base of this technological changes and to address the modern threats faced by military, an advanced sensors equipped robot is introduced with features like landmine detection and utilizes sensors technologies such as metal detectors obstacle avoidance, as well as hazardous gas alerts. The robot can transmit real-time GPS coordinates when detecting a landmine. Also, IR sensors are used to enhance situational awareness and threat detection capabilities.

Keywords— Autonomous Robot, Landmine Detection, IoT, Embedded Design, ESP32.

I. Introduction

Landmines are a major problem looking at the current scenario around the world for military and local citizens residing on the border areas. According to the statement made by the data presented by United Nations, each year almost 10,000 people are injured in sudden war scenarios in which mostly are the citizens from the border areas [1]. According to the report presented by the BBC, the current war scenario in Ukraine has resulted in the deaths of hundreds of citizens due to landmines. A study on landmines revealed that globally, there are 70 countries with hundreds of millions of active landmines. It is estimated that it will take around 100 years or more to detect and clear these landmines [2].

In today's ever-changing and uncertain security environment, there is an urgent need for effective strategies to combat today's threats. The current situation faces many challenges, including change in terrorist tactics, increased bombings, and unstable situation requiring rapid and effective response. Considering these difficulties, a solution needs to be found, and in the background, the automatic mine detection machine is planned to use ESP32 microcontroller, gas sensor, metal detector and infrared sensor as the main innovation.

An automatic mine detection robot is designed to meet these specific requirements, providing a variety of functions such as bomb detection, anti-jamming, and oil detection, fully understanding the challenges faced in security and defense. This summary highlights the importance of this innovation in the current security situation and highlights its important role in reducing risks and protecting lives.

II. Literature survey

Various works related to the automation and integration of IoT in military applications are being introduced day by day. Most of the related works focusing on the model implementation of landmine detection using Ground Penetrating Radar (GPR). For this research several works were reviewed. Research on work presents an automatic decision for landmine detection and classification. Essentially, the system uses gradient-based peak separation technique, wavelet analysis, fuzzy ARTMAP neural network architecture, and global selection. Custom vectors are derived from random responses in metal detector data, including morphological and wavelet-based attributes [1]. Another work The GPR system was successfully validated in a test environment and the effectiveness of the delivery and reception equipment was verified. The system has been shown to be able to detect metal bars as they move on the road. Promising preliminary results show the possibility of using UAVs for real-world reconnaissance, specifically designed to improve the impact signal to solve the problem and reduce system size [2]. Arduino controlled robot for landmine detection using electronic simulations using Proteus include Arduino, ultrasonic sensors, DC motors, and metal detectors. CATIA software was used for conceptual design, providing 2D and 3D views of the robot. The resulting robot is thought to be cheap and robust enough for military use, with many improvements such as suspension, solar panels for continuous power use, and a robotic arm for deployment [3].

An experimental setup includes GPR sensor-based datasets and grade ratios of different soils, ensuring the effectiveness of the research. Concepts and Analysis uses graphical representations to describe changes in class performance across different classes, resulting in a selection table. The table is a useful tool for researchers to guide them in selecting the most effective classification based on specific parameters, soil types, and comparison classes. Overall, this study provides an unbiased understanding of the performance of land surveyors, providing a distinct conceptual framework appropriate to the real situation to make informed decisions in product selection [4]. A Research shows that use a metal detector with a Raspberry Pi, which includes integration of a metal detector with a Raspberry Pi board for on-site monitoring. Metal detectors can detect metal particles in the ground that may indicate the presence of mines. Raspberry Pi acts as the central processing unit, collecting data from the sensor and processing it for further analysis. To provide secure access to the system, an access page was implemented on the Raspberry Pi, allowing users to monitor the discovery process and receive real-time information about threats [5]. Internet of Things (IoT) as a technique for monitoring and analyzing pollution, especially in sewers. The system integrates a calibrated MQ series sensor for CH_4 concentration and Raspberry Pi and GSM module for data communication. The data is sent to the IoT platform ThingSpeak, where it can be instantly accessed and analyzed. The system includes a software-based SMS module for communication and emergency notifications [6]. An unmanned land vehicle combined with metal detectors and robotic arms. The remote comes with an SPST switch for control and uses an RF module to communicate between the vehicle and the user console. Hardware configuration involves connecting modules to create an unmanned vehicle. This process is highly efficient, reduces human impact, and can be used in many situations such as gold mines, military operations, and crowded places. However, restrictions include plastic bomb competition and angle restrictions [7]. Another study investigates the magnetic properties of military training mines, including M14, M15, M16 and M19 mines, as well as metal projectiles and metal rods. Magnetic anomalies were measured at different altitudes using a drone equipped with a three-axis fluxgate magnetometer. M15, M16 and M19 mines at a height of 1 m have a different magnetic field, with the detection of the phenomenon of being affected by the metal content. This study demonstrates the importance of the stability of the drone and keeping the device at an altitude of approximately 1 m to complete my findings [8].

The results show potential improvements such as the addition of security cameras, the use of autonomous machine learning, and search techniques to detect non-metallic mines. Such implementations could benefit and can enhance the security of landmines detection robot. Based on the literature a proposed system utilizing various technologies to achieve effective working of the landmine detection robot.

III. Methodology

Development of the proposed system focuses on the advantage to the military officers who can operate the robot which will sense the metal objects and GPS coordinates can be track also if there's any hazardous conditions like the poisonous gas is present in the surrounding this also can be sensed and notified using the sensors integration. Also, the robot uses obstacle avoidance algorithm to properly transit on the battlefield which makes ease to the soldier to depend on the robot for the updates also there is a hidden cam module used for live video monitoring of the battlefield.

3.1 Proposed System

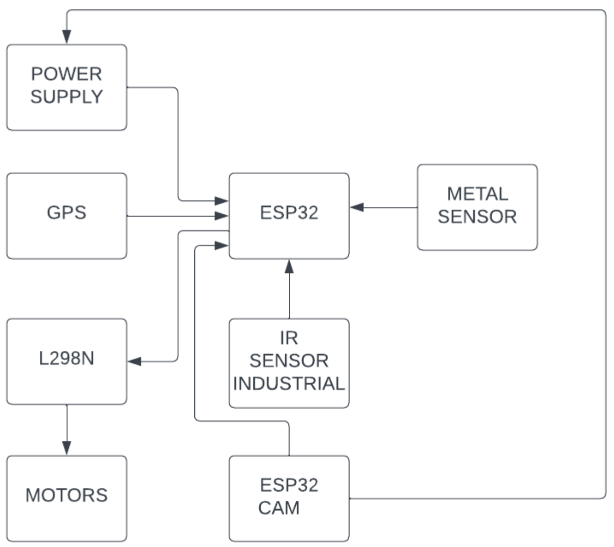

Fig. 1 Block Diagram of proposed system

In the proposed system the main task which should be handled is proper detection of metal objects which can be presented in explosive devices like landmines which contain metal casings, detonators. So, the system uses a metal detector which will detect the metal objects and the operator will get notified with GPS co-ordinates of the detonator. Using a live stream monitoring module, the military personnel can monitor the battlefield.

3.1.1 Circuit Diagram:

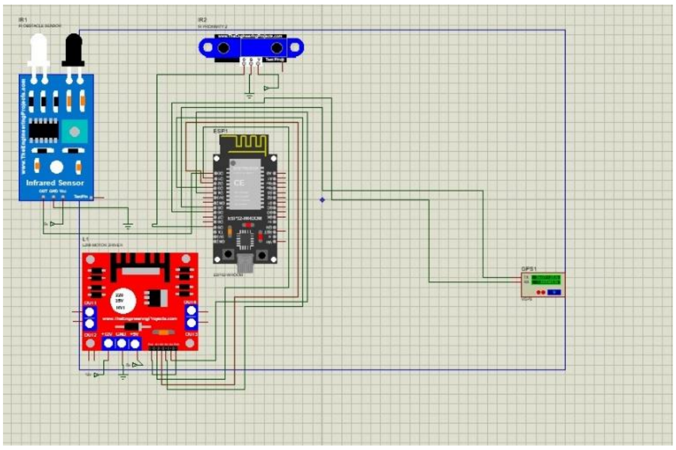

Fig. 2 Circuit Diagram for Proposed System

3.1.2 Working:

The working functionality of the proposed system is broken into sub modules to achieve objective. First modules introduce ESP WROOM32E microcontroller module which act as brain of the system it is responsible for various instructions processing and handling the sensors network in the robot. The second module involves the incorporation sensors including metal object detector and IR sensor. A Metal Detection Sensor for identifying buried metal objects, and an Industrial IR Sensor for proximity and obstacle detection. The third module involves the GPS co-ordinates fetching using Neo6m modules. The GPS Neo 6M Module provides geographical coordinates, while a alert authorities when a potential landmine threat is detected. Final module describes the use of ESP32 Cam module which captures visual information, enhancing the system's ability to assess risks. Also, A motor, controlled by an L298N module, facilitates mobility, enabling the system to move away from threats or navigate obstacles. The ESP32 processes sensor data, makes decisions based on threat assessment, activates alert systems with GPS coordinates, and controls mobility for safe navigation. A reliable power supply ensures continuous operation.

.1.3 Flow Chart:

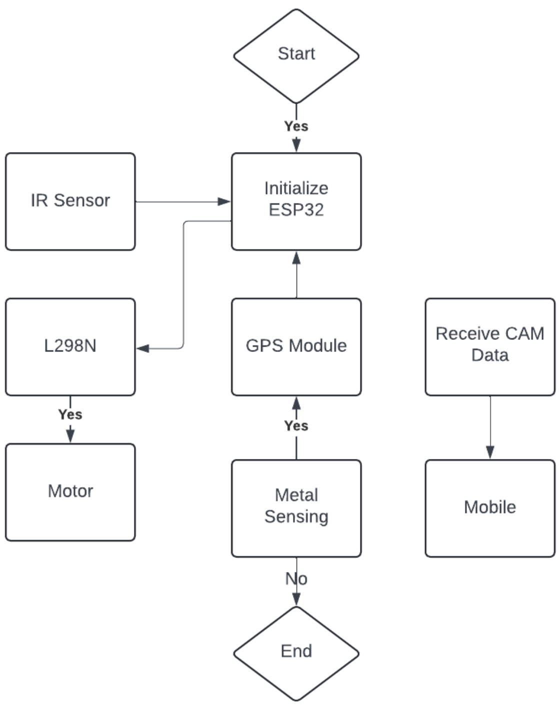

Fig. 3 Flow chart for the proposed system

The proposed flow chart is shown in the above fig. Starting with the initialization of all the sensors and microcontroller. The sensors will start initiating in loop when the metal object is sensed by the metal detector it will trigger the GPS module which will acquire the co-ordinates also the data will be collected to microcontroller for processing. IR sensor will continuously fetch the terrain and if any obstacle is detected in the range of IR the decisions for avoiding will be made from the microcontroller. Finally, the Cam module will work independently irrespective of any decisions. It will send the live streaming data to the user on mobile device or using local IP for conditional monitoring.

IV. Tools and Technology Used

Major components used for the proposed system include ESPWROOM32E Microcontroller module which will process working tasks. A metal detector for metal object detection and another important component is IR sensor which is proximity sensor to detect obstacles in the robots path. For continuous live streaming ESP32 cam module is used.
Also the dc motor and L298N motor driver for controlling the movement of the robot and power supply which is main component which will drive the circuit.

4.1 Applications:

- **i.** Surveillance.
- **ii.** Explosive Device Detection.
- **iii.** Search and Rescue.
- iv. Urban Warfare and Hostile Environments

4.2 Advantages:

- **i.** Enhanced Safety.
- **ii.** Quick Response
- **iii**. Versatility
- **iv**. Improved Situational Awareness

V. Results and Analysis

Based on prior research, the proposed model has added features of data collection for analysis can be possible which ensures the seamless and effective military operations. Below fig. shows the actual prototype implementation and tests executed. Proposed work will possibly reduce risks and will protect lives on the dangerous military operations where the high risks of involved hidden landmines or dangerous environmental conditions could be identified using the sensors network configuration and using IoT the acquired data can be visualized for feedback and analysis of the missions.

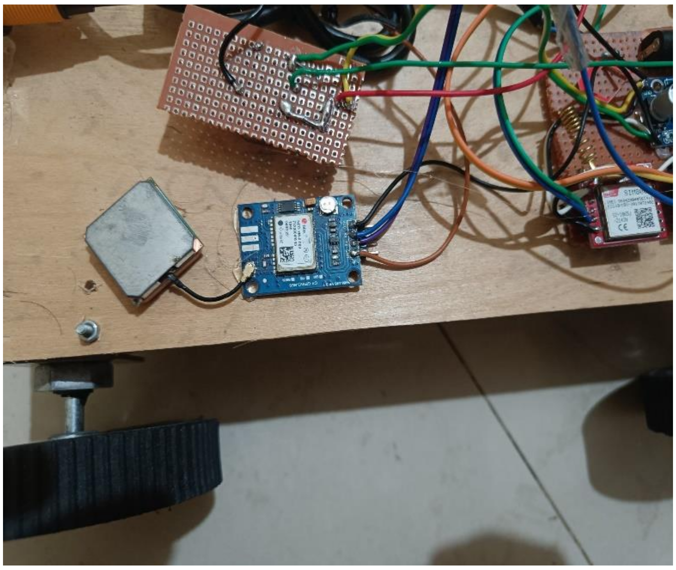

Fig. 4 Proposed System Internal Circuitry

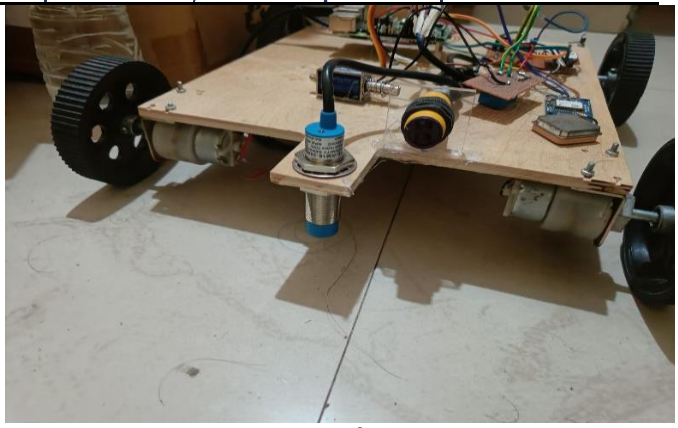

Fig. 5 Proposed Prototype

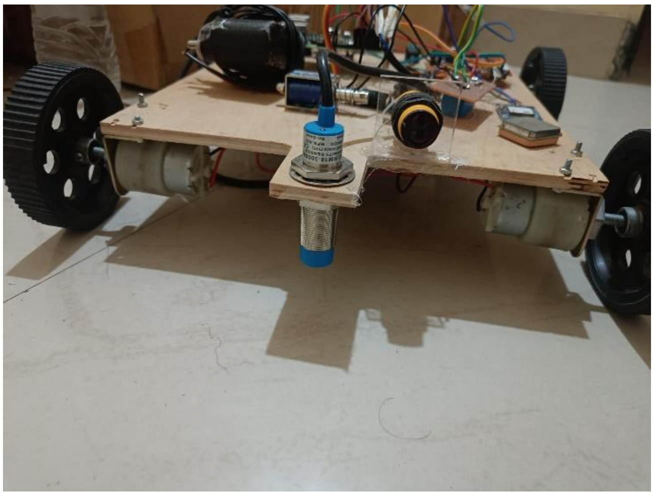

Fig. 6 IR Sensor configuration

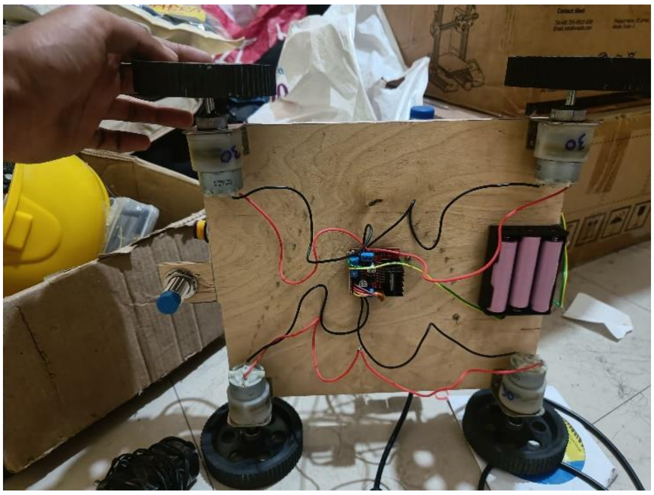

Fig. 7 Motor and Power Supply Configuration

VI. Future Scope

In future the system can be expanded using image processing for proper detection and prediction of enemy movements. Also, the artificial intelligence can be used for improved decision making for precisely detection of the landmines and using audio trans-receiver the battlefield monitoring will be more enhanced and précised for committing the rescue or military operations. These advancements hold great promise for applications in defense, disaster response, law enforcement, and industry, with a focus on increasing safety, efficiency, and autonomy in challenging scenarios.

VII. Conclusion

Safe path detection robot system promises a green initiative towards the technological enhancements in the field of military automation. Utilizing sensor network for automating the military operation provides the life security and efficient alert on the early detection of land mines as well as it will notify user on the atmospheric change. Added advantage with using live cam monitoring feature can use to debug the major battlefield terrain and can track enemy movements.

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