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SPIDER BOT FOR LANDMINE DETECTION

[1]A.VINOTH KUMAR,[2]C.JAVID ANWAR ,[3]S.SIVA PRAKASH , [4]S.VISWESWARAN AND [5]T.SENTHIL KUMAR

[1]ASSOCIATE PROFESSOR, [2,3,4,5]UG STUDENTS

Department of Electrical and Electronics Engineering

P. A. College of Engineering and Technology, Pollachi, Tamil Nadu, India.

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***Corresponding Author: A.VINOTH KUMAR**

ASSOCIATE PROFESSOR, Department of Electrical and Electronics Engineering

P. A. College of Engineering and Technology, Pollachi, Tamil Nadu, India.

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ABSTRACT

The Landmines are still a big threat to people in many areas that have been through a war, killing thousands of people every year. Traditional ways of finding things, like manual probing and trained animals, take a long time, are dangerous, and use a lot of resources. To solve these problems, this project introduces the Spider Bot for Landmine Detection, a robotic system that moves like a spider. The multi-legged design enables stable movement across uneven and hazardous terrain, where wheeled or tracked robots often face limitations. Equipped with suitable sensors, the spider bot can detect buried landmines effectively while minimizing risk to human operators. The project emphasizes safety, cost-effectiveness, portability, and reliability, making it a practical solution for real-world demining applications. Additionally, the study demonstrates the integration of robotics, sensor technology, and autonomous navigation as a step toward - more advanced, scalable, and humanitarian-focused mine detection systems.

INTRODUCTION

Landmines continue to pose a severe threat to human life in post-war and conflict-affected regions, claiming thousands of civilian lives every year. Detecting and removing these explosive devices manually is extremely dangerous, costly, and time-consuming. To address this challenge, technological advancements in robotics and embedded systems have opened up new possibilities for designing automated systems capable of performing landmine detection with minimal human risk. The Spider Bot for Landmine Detection is one such

innovative approach that aims to combine robotic mobility, intelligent sensing, and automation to create a safe and reliable solution for mine detection.

The development of a spider-like robot equipped with multiple sensors and control modules. The robot uses a metal detector sensor to identify metallic landmines buried underground, an ultrasonic sensor to detect and avoid obstacles, and a GPS module to record the exact location of detected mines.An Arduino Nano microcontroller serves as the brain of the system, controlling the movement of the bot through servo motors and processing data from the sensors. The multi-legged "spider" design allows the bot to navigate uneven and rough terrains more efficiently than wheeled robots, ensuring better adaptability in real-world environments.

By integrating these technologies, the spider bot aims to provide a cost-effective, semi-autonomous, and safe alternative to traditional manual mine detection methods. This project not only demonstrates the application of mechatronics, embedded systems, and automation in humanitarian contexts but also lays the foundation for future research in developing advanced robotic systems capable of performing hazardous tasks with greater precision and safety.

Landmine detection is carried out using a combination of manual, animal-assisted, and robotic methods. In manual detection, human operators use handheld metal detectors or prodding rods to locate buried mines,which is highly dangerous, slow, and labor-intensive. In some cases, trained dogs or rats are deployed to sense explosive vapors from mines; although effective, these animals require intensive training, can only work for limited periods, and may be unreliable in harsh environments. Robotic systems have also been developed, most of which are wheeled or tracked vehicles equipped with metal detectors, ground-penetrating radar, or cameras. While these robots reduce the risk to human lives, they often struggle to move efficiently on rough or uneven terrains, and their detection systems are prone to false positives due to metallic debris in the soil. Moreover, advanced technologies used in existing systems are costly, bulky, and complex, limiting their large-scale deployment.

II. METHODOLOGY AND DESIGN

The proposed system is a spider-like multi-legged robot equipped with landmine detection and navigation modules. The design combines mechanical adaptability, sensing technologies, and intelligent control to ensure safe operation in hazardous environments. The spider bot is built on an Arduino Nano microcontroller, which acts as the central control unit, processing sensor inputs and controlling actuators.

The robot's locomotion is achieved using servo motors connected to its legs, enabling stable walking across rough, uneven, or soft terrains where wheeled robots struggle. An ultrasonic sensor is used for obstacle detection and avoidance, allowing autonomous navigation without human intervention. The primary detection component is a metal detector module, which scans the ground for buried metallic objects that may indicate the presence of landmines.

When the metal detector senses a potential landmine, the event is logged and linked with the exact GPS coordinates provided by the onboard GPS module. This ensures precise mapping of hazardous locations for safe demining operations. The system is powered by a rechargeable battery pack with a voltage regulator to supply stable power to all modules.

By integrating mobility, sensing, and location mapping into a single robotic platform, the proposed system enhances the safety, accuracy, and efficiency of landmine detection. The modular design also allows future upgrades, such as the integration of additional sensors (e.g., ground-penetrating radar, camera modules, or wireless communication) for improved performance.

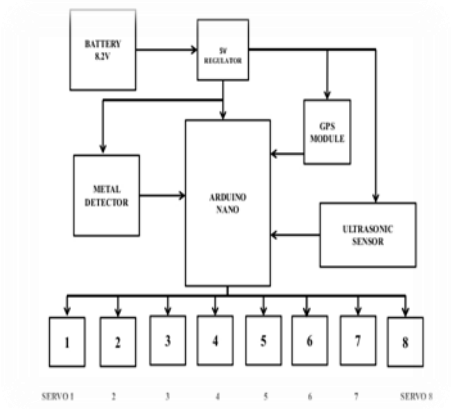

Figure1: Block diagram.

This block diagram represents a detection consists of a central Arduino Nano microcontroller that coordinates the entire system. An 8.2V battery serves as the main power source, and a 5V voltage regulator steps down the supply to provide stable power to the Arduino and the connected modules. The robot is equipped with a metal detector, which acts as the primary sensor for identifying buried metallic landmines, and an ultrasonic sensor for obstacle detection and safe navigation in rough terrain. A GPS module is integrated to record the geographical coordinates of any detected landmine, enabling precise mapping of hazardous zones. The Arduino Nano processes the sensor inputs and controls eight servo motors that

drive the spider-like legs of the robot, providing mobility across uneven surfaces. Together, these modules allow the robot to move autonomously, detect potential landmines, avoid obstacles, and log the exact location of threats for safe and efficient demining operations.

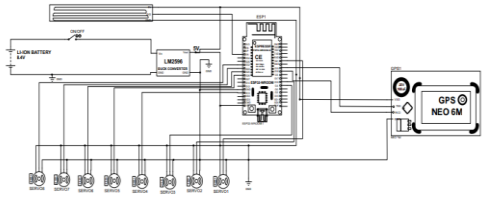

Figure 2: Circuit Diagram.

. Component	Quantity
Arduino Nano	1
NodeMCU (ESP8266)	1
Servo Motors (SG90)	8
Metal Detector Module	1
TP5100 Charger Module	1
2S BMS Module	1
Li-Ion Battery 8.4V (2S pack)	1
LM2596 Buck Converter	1
Switch	1

III. . HARDWARE DESCRIPTION

1. ARDUINO NANO

GENERAL DESCRIPTION

The Arduino Nano is a compact, low-power microcontroller board based on the ATmega328P microchip. It is widely used in embedded systems and robotics projects due to its small size, versatility, and ease of programming. In this project, the Arduino Nano serves as the central control unit of the spider bot, managing sensor input, decision-making, and actuator control.

2. METAL DETECTOR

The metal detector module is a sensor-based device designed to detect the presence of metallic objects buried under the ground. It works on the principle of electromagnetic

induction, where a coil generates an alternating magnetic field that induces eddy currents in nearby metallic objects. These currents produce a secondary magnetic field, which is detected by the sensor circuitry and interpreted as the presence of metal.In this project, the metal detector serves as the primary sensing unit for identifying landmines that contain metallic components. The module outputs a signal when a metallic object is detected, which is fed into the Arduino Nano for processing. Its compact design and low power consumption make it suitable for integration into mobile robotic platforms.The metal detector used is capable of detecting both ferrous and non-ferrous metals within a moderate range, making it reliable for scanning shallow-buried objects. When combined with a GPS module, the detection event can be logged with precise location data, ensuring accurate mapping of hazardous zones.

3. GPS MODULE

The Global Positioning System (GPS) module is an electronic device that receives signals from orbiting satellites to determine its exact geographic location on Earth. It works by calculating the time taken for signals from multiple satellites to reach the receiver, using this data to compute latitude, longitude, altitude, and time information. GPS modules are widely used in navigation, tracking, surveying, and robotics. They are compact, lightweight, and provide real-time location data, making them ideal for mobile and autonomous systems.In the context of the Spider Bot for Landmine Detection, the GPS module enables the robot to record and store the precise coordinates of detected landmines. This allows hazardous zones to be mapped accurately, ensuring safe and systematic demining operations.

4. ESP 32

The ESP32 is a powerful and versatile microcontroller developed by Espressif Systems, designed for Internet of Things (IoT), embedded systems, and automation applications. It is an advanced successor to the ESP8266 and features integrated Wi-Fi and Bluetooth (Classic and BLE) connectivity, making it ideal for wireless communication and remote data monitoring. The ESP32 is built around a dual-core 32-bit Tensilica Xtensa LX6 processor that operates at up to 240 MHz, providing high processing power and efficiency for complex applications. It includes a wide range of peripherals such as UART, SPI, I²C, ADC, DAC, PWM, and GPIO pins, which allow it to interface with various sensors, actuators, and external modules. The chip also supports low-power operation modes, making it suitable for battery-operated systems. Due to its compact size, high performance, and built-in connectivity, the ESP32 is widely used in smart systems, robotics, automation, and IoT-based monitoring applications.

5 .SERVO MOTOR

A servo motor is a rotary actuator designed to provide precise control of angular position, speed, and torque. Unlike standard DC motors, a servo motor is equipped with a feedback control mechanism that continuously monitors its shaft position. This allows the motor to rotate to a specific angle as instructed by a control signal, making it ideal for applications where accurate positioning is required. Servo motors are widely used in robotics, automation, aerospace, and consumer electronics due to their reliability and ease of control.

IV. RESULT AND DISCUSSION

The development of the spider bot for landmine detection demonstrates the practical application of embedded systems and robotics in addressing one of the most critical humanitarian challenges—safe landmine detection. The system was designed with an Arduino Nano as the central controller, which coordinated the inputs from various sensors and controlled the servo motors responsible for the spider-like movement. The bot successfully integrated an ultrasonic sensor for obstacle detection, a GPS module for location mapping, and a metal detector for identifying buried metallic objects, thus proving the feasibility of combining mobility, sensing, and localization into a compact robotic platform. During testing, the spider bot exhibited stable movement on uneven surfaces where wheeled robots typically struggle, confirming that the legged design is more adaptable to rough terrains. The metal detector module was able to sense shallow metallic objects, while the GPS module accurately logged coordinates, enabling the bot to mark potential landmine locations for further investigation. However, the discussion also highlights some limitations. Despite these drawbacks, the project successfully meets its objective of developing a prototype that enhances safety by minimizing human involvement in hazardous environments. The report shows that the spider bot is not only a proof of concept but also a scalable foundation for future research, where advanced sensors, wireless communication, and improved power systems can be integrated to transform it into a practical and reliable solution for real-world demining operations.

V.CONCLUSION

The Design and implementation of the spider bot for landmine detection has demonstrated the effectiveness of combining robotics and embedded systems in creating a safer and more reliable solution for humanitarian demining. By using an Arduino Nano as the central controller, the system successfully integrated a metal detector for sensing buried metallic

objects, an ultrasonic sensor for obstacle avoidance, and a GPS module for precise location tracking, all while achieving stable mobility through a multi-legged design powered by servo motors. The experimental results showed that the spider bot could autonomously navigate uneven terrains, detect shallow metallic objects, and record their positions accurately, thereby reducing the risks associated with manual and animal-assisted mine detection methods. Although the system has some limitations, such as limited detection depth, false alarms due to metallic debris, and restricted power supply, it still proves to be a low-cost, efficient, and innovative prototype that can greatly reduce human exposure to life-threatening environments. The conclusion of this work emphasizes that the spider bot is not just a proof of concept but a strong foundation for future research and development, where enhancements like ground-penetrating radar, AI-based detection, solar-powered energy systems, and wireless data transmission can transform it into a fully practical and scalable demining solution. Overall, the project successfully meets its objectives and highlights the potential of robotics in addressing global safety challenges, paving the way for advanced, autonomous systems that can contribute significantly to humanitarian efforts in post-war regions