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Rocker Boogie Mechanism For Defense System

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Abstract

This paper addresses the critical issue of landmine clearance by proposing a robotic solution for safe and efficient detection and marking. Traditional methods, often involving manual detection or mine-sniffing dogs, endanger human lives. This research proposes a landmine detection and marking robot, remotely controlled from a safe distance via wireless technology. The robot employs a suite of sensors to identify and pinpoint the precise location of buried landmines. Metal detectors are a primary tool, but the design can incorporate additional sensors like ground penetrating radar or thermal imaging for improved accuracy across various mine types. The robot's navigation system is crucial. A four-wheeled, high-mobility suspension system allows the robot to traverse uneven terrain often found in minefields. This ensures thorough exploration and minimizes the risk of human deminers needing to access hazardous areas. Beyond detection, the robot will be equipped with a unique landmine marking system. This system could involve paint markers, flags, or even data transmission to a central control station for digital mapping of mine locations. This real-time data would be invaluable for both demining efforts and future land use planning. Creating a fully functional prototype that has these features is the ultimate objective. The prototype will utilize GPS for autonomous movement, allowing the operator to define search patterns and minimize manual control. This level of autonomy further reduces human exposure to danger zones.

Keywords:

GPS, Landmine Detection, Landmine Marking system, Suspension System, Data Transmission System

1. INTRODUCTION

The global landmine crisis is a pressing humanitarian issue. Estimates suggest over 500 million unexploded mines lie dormant in approximately 50 countries [1]. These insidious weapons claim countless civilian lives and limbs daily, prompting governments and international organizations to prioritize landmine clearance efforts [2]. This paper proposes a solution: a landmine detection and marking robot designed to make demining operations safer and more efficient.

The proposed robot would utilize a suite of sensors to identify and pinpoint the precise locations of buried landmines. Metal detectors would form the core detection technology, but the design could be augmented with additional sensors like ground penetrating radar (GPR) or thermal imaging for improved accuracy against diverse mine types [3]

The project's ultimate goal is to develop a fully functional prototype integrating these functionalities. The prototype would utilize GPS for autonomous movement, allowing the operator to define search patterns and minimize manual control, further reducing human exposure to danger zone.

The proposed robot design necessitates the incorporation of wireless data transmission capabilities to ensure seamless communication with operators while operating remotely. This feature is indispensable for the safety of operators, allowing them to maintain a safe distance from potentially hazardous environments such as minefields. In the realm of modern warfare, landmines serve as cost-effective and strategically potent tools, capable of impeding enemy movement across vast territories. These insidious weapons are often deployed in clusters, forming minefields strategically positioned to either channel adversaries into specific areas or deter them from traversing particular routes.

With over 350 distinct types, landmines can be categorized broadly into two main classifications: anti-tank and anti-personnel mines. Anti-personnel mines are engineered to inflict harm or fatal injuries upon enemy combatants. Typically buried at depths ranging from 10 to 40 millimeters beneath the surface, these devices require a minimum pressure threshold of approximately 9 kilograms to trigger their explosive mechanisms. Characterized by face diameters typically falling between 5.6 and 13.3 centimeters, anti-personnel mines are designed to inflict maximum damage within a confined radius upon detonation.

The significance of wireless data transmission capabilities in the proposed robot design cannot be overstated, as it enables operators to remotely control and monitor the robot's activities in hazardous environments such as minefields. By facilitating real-time communication between the robot and its operators, this feature enhances operational efficiency while safeguarding human personnel from potential harm. Moreover, the ability to function remotely ensures that operators can maintain a safe distance from the inherent dangers posed by landmines, mitigating the risks associated with manual demining operations.

In essence, the integration of wireless data transmission capabilities in the robot design represents a critical advancement in modern demining technologies, enhancing the safety and effectiveness of mine clearance operations. As landmines continue to pose significant threats to civilian populations and military personnel worldwide, innovative solutions such as remote-operated robots equipped with wireless communication capabilities play a pivotal role in mitigating these risks and facilitating the safe clearance of hazardous areas.

2. OBJECTIVES

- Reconnaissance and Surveillance: Reconnaissance and surveillance involve deploying sensors to collect immediate data in risky locations, enabling the acquisition of vital intelligence about potential threats or hazard**s.**
- Support: Support involves transporting provisions through challenging terrain, lessening the load on soldiers and enhancing their operational effectiveness.
- Combat Operations: Combat Operations encompass offering covering fire and tactical aid to troops engaged in

battle, enhancing their effectiveness and operational success.

- Autonomous Navigation: Autonomous navigation refers to the ability of a system or vehicle to move independently through intricate environments, ensuring safe and efficient traversal without human intervention. It relies on advanced algorithms and sensors to perceive surroundings, make decisions, and navigate obstacles, enabling autonomous vehicles to reach their destinations effectively.
- Risk reduction: Risk reduction involves safeguarding soldiers by conducting operations in perilous environments with strategic planning, equipment, and training, minimizing potential dangers and enhancing overall safety during missions.
- Mine Detection: Mine detection entails the identification and marking of landmines using specialized equipment and techniques to prevent casualties among troops and civilians. This process involves the systematic scanning of terrain to locate hidden mines, allowing for their safe removal or avoidance, thus mitigating the risk of injury or death.
- Extended Operation: Extended operation involves maintaining functionality over prolonged periods to maximize effectiveness, often achieved through efficient resource management, robust infrastructure, and strategic planning.

3. SOFTWARE DESIGN

The paper outlines two distinct programs crucial for achieving the project's objectives. Firstly, the transmitter section's programming is entirely implemented using MATLAB. This involves the creation of a graphical user interface (GUI) tailored for controlling the robot from a laptop. Pushbuttons on the GUI are used to provide directional commands, including moving forward, backward, left, or right. Additionally, it features a video streaming window to provide visual feedback and a radio button to facilitate the establishment of communication between the laptop and the robot.

Secondly, the receiver section entails embedded programming, which is responsible for overseeing the comprehensive control of the robot's movements. This aspect involves writing code that manages various aspects of the robot's behavior, including interpreting commands received from the transmitter section, coordinating motor movements, and ensuring overall operational efficiency. Embedded programming is essential for executing real-time control and ensuring seamless interaction between the robot and its environment.

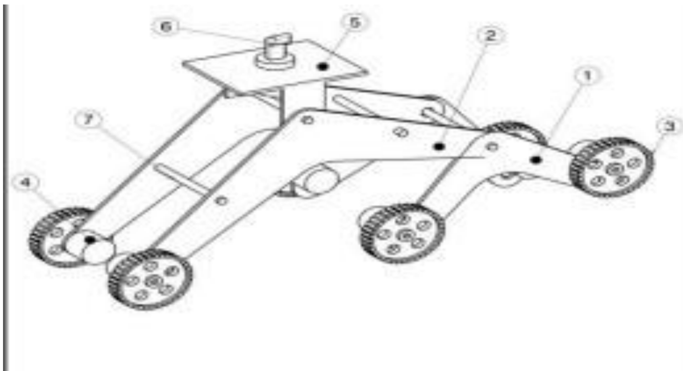
4. HARDWARE DESIGN

The ATmega16 microcontroller serves as the central processing unit in the project's hardware setup, providing the intelligence and control necessary for effective operation. With its 40-pin configuration, it offers ample connectivity options through its four ports labeled A, B, C, and D. Each port facilitates communication with external devices and peripherals, enabling seamless integration and control within the system. Key components of the system, such as the RF Transceiver, are intricately linked to specific pins of the microcontroller to facilitate essential functions. In this case, the RF Transceiver is connected to Port D's PD0 and PD1 pins, designated as the transmitter and receiver pins, respectively. This configuration establishes a robust communication channel vital for transmitting and receiving data wirelessly, facilitating seamless interaction between the robot and its operators or control systems.

Moreover, precise timing and synchronization are ensured through the connection of pins 12 and 13, known as XXTAL1 and XTAL2, to a 25MHz crystal oscillator circuit. This oscillator circuit provides stable clock signals essential for coordinating the timing-sensitive operations of the microcontroller, ensuring reliable and efficient execution of tasks. The integration of the L293D motor driver IC further enhances the microcontroller's capabilities by facilitating motor control for robotic locomotion. Precise control over motor motions is made possible by connecting pins 2 and 7 of the L293D motor driver IC to pins PB0 and PB1 of the microcontroller. The motors themselves are connected to specific pins of the L293D, with pins 3, 6, 11, and
14 representing the left and right motors. Proper voltage regulation is ensured by connecting pin 16 of the L293D to VCC and pins 4, 5, 12, and 13 to ground.

The power supply unit, comprising a transformer, rectifier, capacitors, and regulator, plays a crucial role in providing stable power output to the entire system. Outputting 5V from a 12V input, this power supply unit ensures that all components receive the necessary power for reliable and efficient operation. Additionally, LEDs can be incorporated into the system for mine detection indication, offering visual cues to operators or nearby personnel. These LEDs can be connected to any microcontroller port, with Port D being commonly used due to its ample pin availability, allowing for flexible integration and customization.

5. STRUCTURE OF ROBOT



Sr.No	Component Name	Quantity
1	Arm 1	2
2	Arm 2	2
3	wheel / Leg	6
4	Motor	6
5	Top Frame	1
6	Camera	1
7	Support Fixture	4

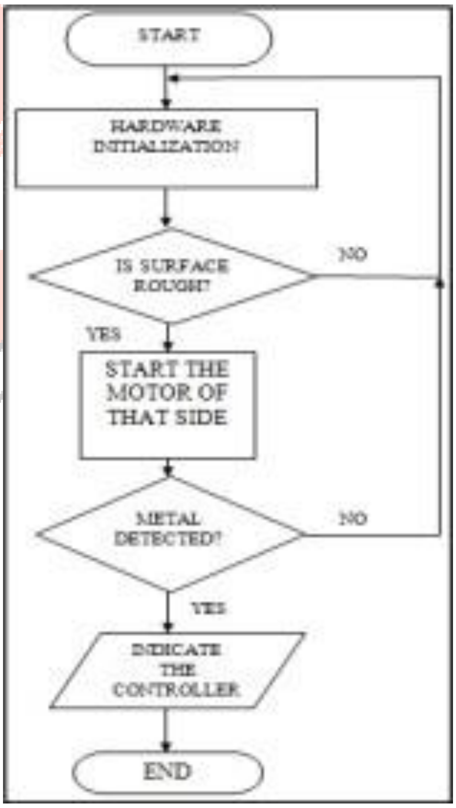
The components of the robot itself are divided into seven parts. The parts are indicated using the index below the figure.

1. Component 1 refers to the robot's Arm, with two identical arms situated at the front. These arms possess joints that are activated solely on rough surfaces, as detailed in Section 4 of the working description. Conversely, on smooth surfaces, these arms remain rigid and operate linearly.
2. These additional arms, referred to as the backward or inner arms, are longer in length. Unlike the front arms, they lack joints and remain consistently active. The interconnectedness of the back and front arms via joints is pivotal to the robot's functionality.
3. Component 3 comprises the wheels, primarily employed for propelling the robot akin to a vehicle. The wheel dimensions will be tailored to suit the size of the robot.
4. Part 4 consists of six motors located at the extremities of the arms. These motors will be positioned opposite each other, back-to-back, with the wheels connected to them.
5. Component 5, known as the top frame, serves as the platform for mounting the camera used for video streaming. In our project, we opt to utilize a phone for direct video streaming to our PC. Therefore, the top frame can also function as a holder or support for the phone. While initially flat, the design of the top frame can be customized according to our specific requirements.
6. The camera, whether an IP webcam or a phone, can be utilized for video capture. It will be installed on the top frame, as depicted in the figure.
7. The final component is the support fixture, designed to hold the robot's components together securely. Four support fixtures will be employed, with three dedicated to supporting the arms and one for securing the top frame along with the arms. These fixtures serve to prolong the robot's lifespan by preventing both breakage and loosening of component connections.

6. SYSTEM SPECIFICATIONS

1. RF Module:
   - RF module operates within a 30-meter range with an onboard antenna.
   - Temperature range for RF module operation: -40 to +85°C.
   - RF frequency availability: 2.4 to 2.483GHz.
2. ATmega16:
   - Operating voltage range of ATmega16: 4.5 to 5.5 V.
   - Speed grade for ATmega16: 0 to 16MHz.
   - AVR 8-bit microcontroller with high performance and low power consumption, capable of single clock cycle execution.
3. RF Transceiver:
   - FSK Transceiver module.
   - Compatible with 2400-2483.5 MHz ISM/SRD band systems.
   - Utilizes a 3-wire digital serial interface and a complete Phase-Locked Loop (PLL) for precise local oscillator generation.
4. L293D:
   - Motor driver IC.
   - 16-pin IC capable of controlling two DC motors simultaneously in any direction.
   - Internally integrated diode for Transient Suppression.
5. Motor:
   - PENTA DC Motor.
   - Features a robust and simple design with long working life.
   - Output power ranges from 45 to 1500 W.
   - Equipped with ferrite permanent magnets.
6. Battery:
   - Dimensions: 100(L) x 50(D) x 70(H)mm.
   - Charging current: 720mA for 10-14 hours.
   - Discharge current: 20 hr rate 350mA.
7. Proximity Sensor:
   - Dimensions: 4(L) x 1(R)cm.
   - Detection range: 0.7 mm.
   - Requires a 12V power supply.
8. Buzzer:
   - Compact design.
   - Audible sound range extends up to 50 meters.

7. FLOWCHART



1. The initial step always involves starting the process.

2. Hardware initialization constitutes the second step, encompassing tasks like setting up the project's equipment, including the controller and the robot, in an appropriate environment for mine detection.

3. This stage involves determining if the surface is rough,

serving as a decision-making phase. a) If the surface is rough, the robot activates the motors at the front end and their connected joints to utilize the rocker-bogie mechanism, enabling smooth movement in all directions and on various surfaces. b) If the surface is not rough, only the motors are enabled as the robot is required to move on a flat surface, and the process proceeds back to the hardware initialization step.

4. Progressing further, this step entails another decision point: detecting metal. a) Upon metal detection, the robot halts, and the sensor alerts the controller. b) If no metal is detected, the robot continues its forward movement.

5. Once metal is detected, the robot notifies the controller using indicators such as buzzers, facilitating the subsequent diffusion of the mine.

This marks the conclusion of the robot's operations.

8. SYSTEM CHARACTERISTICS

The robot boasts a remarkable 90% detection rate for both anti-personnel and anti-tank mines, utilizing a highly sensitive metal detector system. Its design incorporates an innovative mine traversal mechanism, ensuring smooth movement across varied and challenging terrains encountered in minefields. By operating remotely and featuring wireless data transmission capabilities, the robot prioritizes operator safety, eliminating the need for human presence in hazardous environments.

Equipped with a sophisticated differential drive steering system, the robot exhibits exceptional maneuverability, enabling movement in all directions with precision. This capability allows it to detect potential buried mines effectively while efficiently clearing 1.3-meter-wide lanes in a single pass. With a scanning capacity of 200 square meters per hour, the robot demonstrates impressive efficiency in covering expansive areas within minefields.

Furthermore, the robot platform is thoughtfully designed to accommodate a mobile phone, seamlessly integrating it into the operational setup. This integration enables real-time video footage of the robot's path to be transmitted via a dedicated app, offering operators comprehensive visibility and situational awareness. Such features not only enhance operational monitoring but also facilitate informed decision-making during mine-clearing missions, ultimately contributing to safer and more efficient demining operations.

9. CONCLUSION

The successful demonstration of the proposed landmine exploration platform underscores its effectiveness in enhancing battlefield safety, particularly for soldiers facing the threat of hidden mines. With the capability to clear paths up to 1 meter in width in a single pass, the platform significantly reduces the risk of accidental detonations and injuries caused by landmines. A key advantage of the platform is its ability to transmit the precise location of buried mines to operators in real-time via a dedicated video app. This feature allows personnel to safely navigate the terrain by following the robot's tire tracks, mitigating the danger of encountering mines and minimizing the potential for harm. By providing crucial information about mine locations, the platform empowers operators to make informed decisions and take necessary precautions while conducting operations in mine-affected areas.

Moreover, the platform's design not only addresses the immediate need for landmine detection and marking but also opens up new avenues for further research and innovation in the field of mine clearance technology. As advancements continue to be made, the potential for improving safety and efficiency in demining operations grows, ultimately contributing to the protection of innocent civilians living in conflict-affected regions. Furthermore, the integration of a camera connected to a laptop via a phone streamlines the process of monitoring the surroundings through live video footage. This additional feature enhances situational awareness and facilitates real-time decision-making, further enhancing the effectiveness of the platform in mitigating the threat posed by landmines.

10. FUTURE SCOPES

The future scope of the rocker-bogie mechanism involves advancements and potential applications in various fields.

1. Terrestrial Robotics: Adaptation for terrestrial robots used in search and rescue operations, environmental monitoring, agriculture, and other applications where navigating rough and uneven terrain is crucial.

2. Autonomous vehicle Integration into autonomous ground vehicles, including those used for logistics, transportation, and surveillance in urban and industrial environments.

3. Mining and Construction: Implementation in mining and construction robots for exploration and operation in harsh and difficult-to-reach environments. The mechanism's ability to traverse uneven terrain can be advantageous in these applications.

4. Environmental monitoring Integration into robotic platforms designed for environmental monitoring, such as studying ecosystems, monitoring wildlife, or assessing the impact of natural disasters.

5. Modular Robotics Development of modular robotic systems that can adapt the rocker-bogie mechanism for specific tasks. This will enable modification and optimization according to the demands of various applications.

6. Humanitarian Aid: Utilization in humanitarian aid scenarios, such as disaster response and relief efforts, where robots equipped with the rocker-bogie mechanism can navigate through debris and challenging environments.

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