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Design of a Remote-Controlled Metal Detector Robot

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Abstract **–** This paper describes the design, implementation, and testing of a remote-controlled metal detection robot. The robot capable of detecting metal objects can be used in searching landmines. Metallic objects at a distance of 15 centimeters can be detected. The metal sensor has a copper coil that senses the variation in the magnetic field due to the presence of a metal object. In the robot, track wheels are used to have high maneuverability. Two DC motors are used to rotate the wheels. L298N H-Bridge module is used to control the DC motor. In addition, GPS locations of detected metal objects are recorded. To control the electronic system remotely, an ESP8266 module is used. The implemented robot was tested in several trials. These tests validated the robot's ability to detect metal objects.

Keywords – Metal Detector, Landmine Detection, Robotics, Analog Circuits

I. Introduction

This conference paper describes the development of a robotic vehicle that scans an area and detects metallic objects. Metal detection robots are deployed for archaeology and security applications. The most important application is landmine detection. Considering that there are approximately 110 million land mines around the globe that are waiting to be cleared, landmine detection is a problem of significant humanitarian concern. Robotic systems that can safely find landmines buried under the soil are vital for reducing human life risks in landmine clearance operations. The realization of landmine detection robots requires the involvement of researchers. Consequently, several researchers have conducted research to provide reliable robotics solutions for the landmine detection problem [1-5].

II. Materials and Method

The system design of the robotic vehicle consisted of mechanical design, hardware design, and software design. Each part is explained in detail separately under subheadings.

A. Mechanical Design

The mechanical part of the robot consists of body and wheels. The robot's body contains all electronic components. A 3D printer was used to create the body. Wheels mounted on each side of the robot body are used to move the robot. Pallet wheels are chosen since they are more functional on sloped terrains, compared to standard wheels. The robot's body and pallet wheels are shown in Figure 1.

Fig. 1 Robot body and wheels

B. *Hardware Design*

The designed hardware consists mainly of a metal detector circuit and a motor driver circuit. The circuits were fabricated using printed circuit boards. In addition, batteries are used to provide power to the robotic system. Figure 2 shows the developed robot.

Fig. 2 The robot.

The main component of the metal sensor is the copper coil. The sensor uses an air core coil that senses the variation in the magnetic field caused by the presence of a metal object. The copper wire about 0.5 mm in diameter is wound 32 turns. The resistance of the coil is 40 ohms. The coil part is externally mounted on the robot's front end (see Figure 3).

Fig. 3 The coil.

The metal sensor is an analog circuit that uses a 555 IC timer as an oscillator. The circuit that processes the signal obtained from the 555 IC timer is shown in Figure 4. The rectangular signal generated by the 555 timer is input to the gate of the Q1 transistor. The signal is amplified at the amplification stage. When a metallic object is nearby, the frequency of the signal changes. With this change, the Q2 transistor is turned on and the buzzer starts buzzing. The circuit can detect metals at a depth of 15 centimetres.

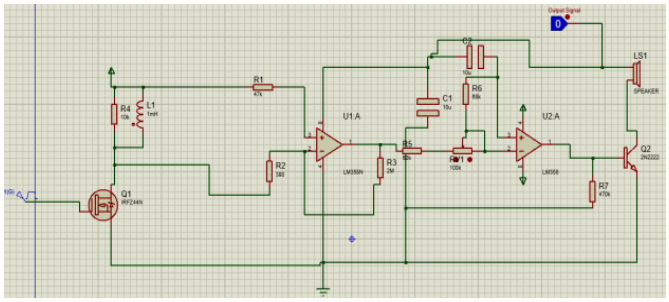

Fig. 4 The schematic of the sensor circuit.

The system uses two DC motors to rotate the wheels. L298N H-Bridge motor driver IC is used in the motor control circuit for adjusting the speed and direction of these two motors. There are two H-bridges in the L298. Two motors are controlled individually and in both directions by the H bridges. The duty cycle of the PWM signal generated by the L298 determines the motor speed.

C. *Software Design*

The low cost ESP8266Wi-Fi chip is used to serve as the robot's brain that controls the movements. The chip was programmed in C language. The robot is controlled manually with a mobile phone, using the Wi-Fi feature of the ESP8266. When the robot detects a metallic object, the interrupt pin of the ESP8266 is triggered, and the robot automatically stops. It sends the GPS location of the metallic object to a web server with ESP8266. Furthermore, the current position of the robot is tracked, and the robot is controlled to navigate to a certain area using GPS.

III. RESULTS

After the completion of the implementation, the testing trials of the developed robotic vehicle were carried out on campus terrain. The movement of the robotic vehicle was controlled wirelessly with a mobile phone. It was observed that the robot was able to navigate perfectly, even on sloped terrains. This allows the robot to search areas in difficult environments. During the tests, the robot was used for scanning the terrain for metallic objects. The robot was able to detect metallic objects along its path, and users were informed of detections with a buzzer. Any metallic object buried under the soil at a depth of maximum 15 centimetres was

successfully detected. The GPS locations of detected metallic objects were recorded. The tests confirmed the ability of the robot to detect buried landmines.

IV. DISCUSSION

We developed a prototype of a metal detection robot. Care was taken to ensure that the robot was effective and low-cost. As future work, the robotic vehicle's ability to work in difficult terrains can be improved by using more functional wheels. If the cost of the robot was not an issue, additional features such as camera-based obstacle detection and avoidance would be added.

V. CONCLUSION

In this paper, a remote-controlled metal detection robot is developed. The main application of the constructed robot is its ability to detect landmines without risking human life. The design consists of three parts: the mechanical design, the hardware design of sensor and motor control circuits, and the software design to control the system.

The robotic vehicle has pallet wheels that provide efficient movement in all terrain conditions. The motor driver circuit based on L298 IC provides maneuverability during the area search. The metal detector that was constructed with a coil sensor can sense the presence of metals at a depth of 15 centimetres. When a metallic object is detected, the robot gives a warning with a buzzer. The positions of metallic objects are recorded with the help of GPS. Completed tests prove the success of the robotic vehicle in detecting metallic objects.

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