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Design of Arduino-Based Metal Detector Robot

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Abstract- Metal Detector Robot is an instrument controlled by an Android-based smartphone that detects the presence of metal, especially landmines, on a designated location. The usage of landmines causing injury and fatality makes detectors important. The old method of detecting landmines such as direct sweeping is very risky for stepping the landmine unintentionally. In this research, the robot system is equipped with a metal detector useful to detect the metal presence based on coil induction when it's approaching the metal. LCD works as an interface showing frequencies of detected metals. The robot movement is controlled by DC's current motor programmed using Arduino UNO. When the robot detects the metal presence, the buzzer sound will be triggered, and the LCD will show the detected metal frequency. The testing result shows that an Android-based smartphone can control the robot up to 15 meters radius. The detection radius is effective up to 88 millimeters from the detector head.

Keywords- arduino uno, metal detector, design, robot

I. INTRODUCTION

We know a variety of materials including metal and non-metal materials. Non-metal materials that we know include wood, plastic, and other materials that are often used in everyday life. In general, metals are divided into ferrous metals and non-ferrous metals [1]. In everyday life, metal materials are usually used to conduct electricity, cooking utensils, jewelry, even for military purposes, one of which is the material for defense equipment such as mines. What we know in the military world, mines are usually planted below the surface of the ground, so that if they are pressed heavily, a mass trampled object will explode. Mines contain explosives that have certain physical and chemical properties [2], [3].

The existence of mines buried in the ground is difficult to know without the aid of tools. One of the tools used to detect the presence of mines is a metal detector [4]. Metal detectors contain a coil of wire known as a transmitter coil. When electricity flows through the coil, a magnetic field is created around the coil. When metal detectors are moved above the ground, the magnetic field will also move. When held close to a metal object, the magnetic field will affect the atoms inside the metal, even changing the way electrons move. The weakness of this metal detector is the high risk of victimization to users because its use still relies on direct human intervention.

Ease of doing a job is now a human need in carrying out its activities so that humans develop a breakthrough in utilizing technology. Utilization of technology to save time and costs. One solution to meet these needs is to use robotics technology that will help even replace some aspects of human work [5].

The use of robots as a tool, of course, is made as closely as possible with what humans do. Some robots are designed to have arms [4], robots that can follow certain colors [5] - [7], robots that can deliver food [8], robots that can guide parking [9], and of course those that are currently developing in connection with the outbreak. Covid-19 is a robot that can shop for daily necessities without the owner having to come to a supermarket or shop [10].

Smartphones communicate with the robot using a radio network (wireless) with the protocol Bluetooth. The data is sent by a cellphone via Bluetooth and received by the robot via adapter Bluetooth. The received data is modulated into serial data with ASCII format. The ASCII code is verified by the program to determine which commands to run. Metal detectors work based on the induction of metal objects in the

enamel coil. The electric induction caused by the coil will change between the presence of metal and no metal. Based on these changes, the metal presence or not can be detected [7].

Metal detection robots are tools to detect the presence of metal or materials containing metal, this robot will notify the presence of metal around the robot by using light or sound [8], [9].

Research on metal detection robots has been carried out by several researchers to produce a metal detection robot design as desired [11] - [13]. Metal detection robot studies were developed based on a microcontroller, to make programming easier. Among them is a metal detection robot based on a microcontroller [11]. Several recent studies in robot design are based on Arduino [9], [14], [15], or some research based on Android [16]. The results of his research describe the application of using an inductive proximity sensor in a metal detector robot based on a 328 microcontroller. The way this robot works is controlled by a wireless remote radio frequency of 315 Mhz, previously a metal detector robot has installed a receiver with a signal that comes out of the wireless remote [12]. The previous metal detector robot was also entitled metal detector for the PLC-based food industry in 2011 [13]. Currently, PLC-based control is still widely used in industries whose equipment uses large power equipment, including in the food industry. The addition of a metal sensor will make it easier to detect food if it is accidentally mixed into food [17].

The purpose of this research is to design an android-based metal detection robot, which can be controlled by a smartphone connected to Bluetooth, with the reliability of being able to detect both ground and underground metals.

II. METHODS

A. Schematic of metal detection robot

This process describes the robot scheme to be built. This scheme is made to simplify the design process because the grooves or cable connections have been validated using the proteus software.

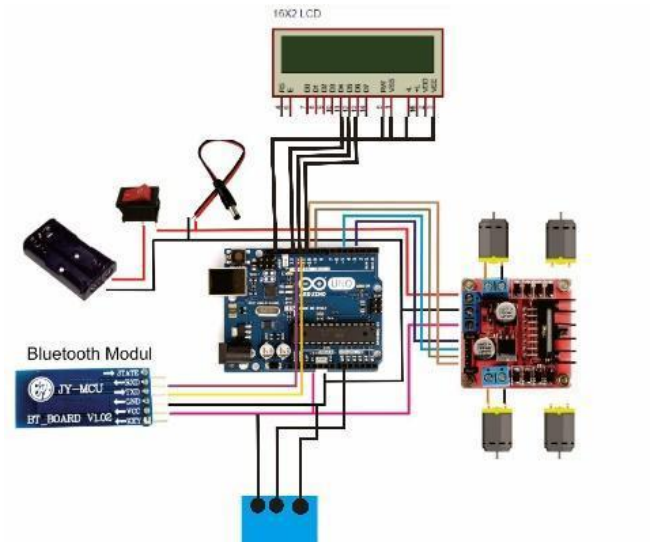

Figure 1. Scheme of metal detection robot

B. Robot Design

1) Frame

The robot is designed using 2 frames, both of which are made of acrylic material with dimensions of 250 mm x 140mm x 3mm, as shown in Figure 2.

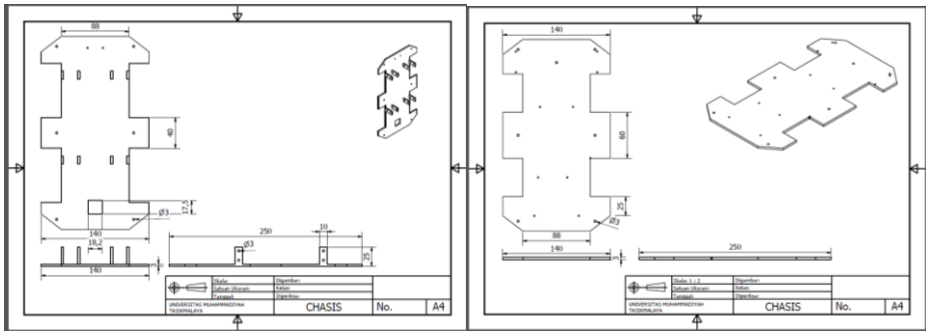

Figure 2. Frame

2) Gearbox (DC motor)

The drive used for this robot is to use a DC motor [14]. The use of a gearbox is needed to make efficient space on the chassis and change the shaft position of the DC motor because by using a gearbox, a dc motor that should be placed horizontally to distribute its rotation to the wheels can be positioned vertically with a fixed axle.

Figure 3. Gearbox (DC motor)

3) Metal sensor

This component is the most important part in the design of a metal sensor robot, with this component where the detected metal can be detected. For this study, researchers used metal sensors with the following specifications [7]. (a) Detection distance: 0-8mm; (b) Object of detection: Metal (Iron, Aluminum etc.); (c) Working voltage: 10-30V DC; (d)current Output: 300mA; (e) There are indicators: Yes (Red); (f) Working temperature: -25 to +70 C; (g) Size: 18x18x36 mm; (h) Cable length: 1.5m; (i) 34mm x 18.2mm x 17.5mm.

Figure 4. Metal sensor

4) Buzzer

This component is a component that converts electricity into sound. The buzzer will output the metal sensor robot. This tool will notify by emitting a sound when the metal sensor detects the presence of metal.

Figure 5. Buzzer

5) Battery

This component is the power supply in metal detection robots. The battery used is a battery with a current of 9V, this battery is considered sufficient to supply all the electrical needs of the metal sensor robot, from starting to turn on 4 DC motors, motor drivers, Arduino, metal sensors, buzzer, and LCD dot matrix.

Figure 6. Battery

6) Arduino

Arduino is a board microcontroller, this tool will fully control the robot system from input and output according to what is ordered or programmed on the computer.

7) Motor driver

The motor driver is used to control the direction of rotation and speed of the DC motor [18] - [20], which is the main driving force of the robot. This motor driver will be controlled using a microcontroller by digital input data [7].

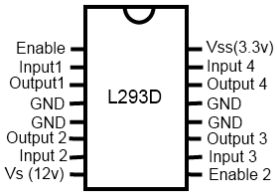

Figure 7. L239D pin configuration

8) LCD dot matrix

Character numbers, letters, and symbol characters can be displayed on this device, with small current consumption.

Figure 8. LCD Dot Matrix

C. Software Design

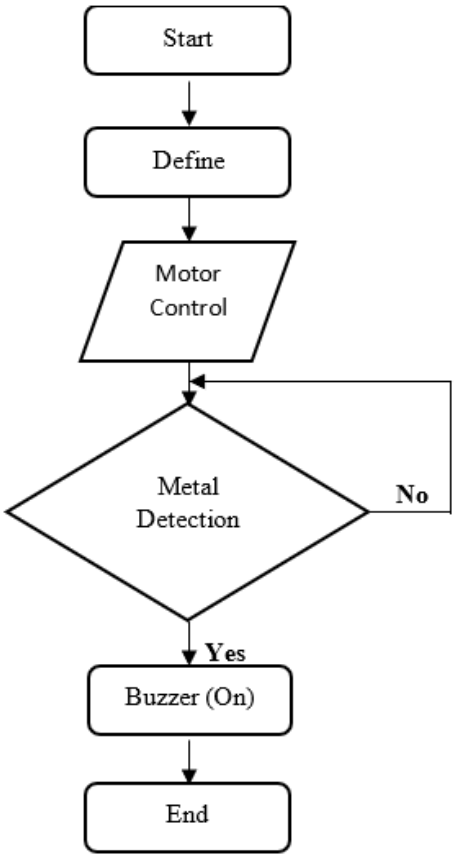

Figure 9. Flowchart of software design

D. Testing Stages of detector metal with metal variations and distances

Metal detector testing plans are shown in **Table** 1.

TABLE 1. Testing of metal detector

Metal Type	**Distance (cm)**	***Buzzer***	
		On	**Off**
Aluminium	0,5		
	1		
	1,5		
Iron	0,5		
	1		
	1,5		
Copper	0,5		
	1		
	1,5		

E. Robot reliability testing

In This testing phase we will measure the strength of the robot in climbing a slope of 30^0.

TABLE 2. Robot reliability testing on an incline

Number	PWM	Result	Information
1	255		
2	240		
3	200		
4	180		
5	160		

III. RESULTS AND DISCUSSION

A. Results of the Tool Design

1) Software

In the form of programs, the Arduino software program was used as the controller of all components of the robotic device. Arduino UNO is programmed using Arduino software as shown in Figure 10.

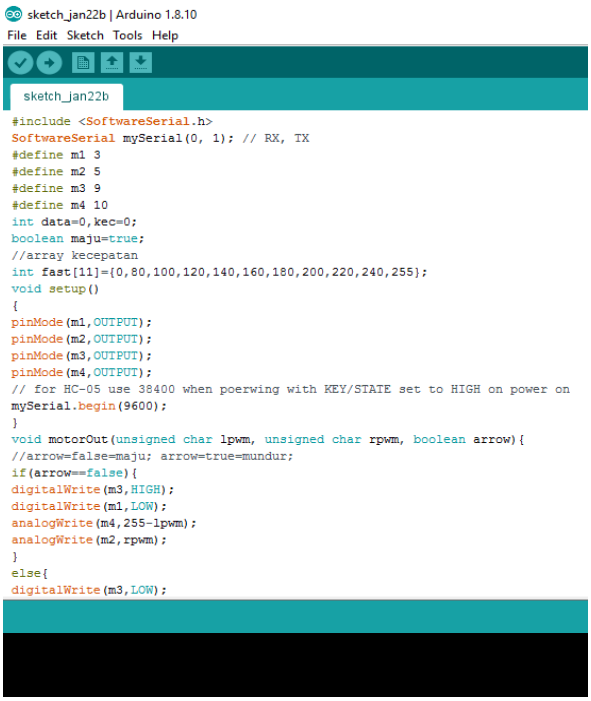

Figure 10. Program listing

B. Hardware

1) Design Frame

The mainframe of the robot is acrylic. The choice of acrylic material as the chassis is because it is strong, cheap, and easy to form with a size of 140 mm x 250 mm x 3 mm. The robot frame is divided into 2 parts, namely the lower part of the frame which is the support for 4 DC motors, metal sensors, a battery, and support for the upper frame. The upper part is a holder for Arduino, motor driver, buzzer, LCD, which can be seen in **Figure 11**.

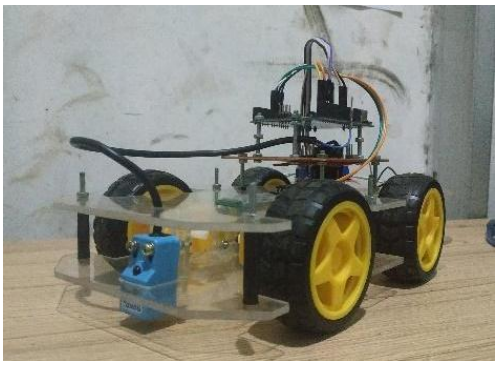

Figure 11. Results of design

2) The DC circuit

Robot use 4 dc motors as the main drive, this DC motor circuit (Figure 20) is connected to the L298N motor driver which functions to determine the direction of rotation of a dc motor.

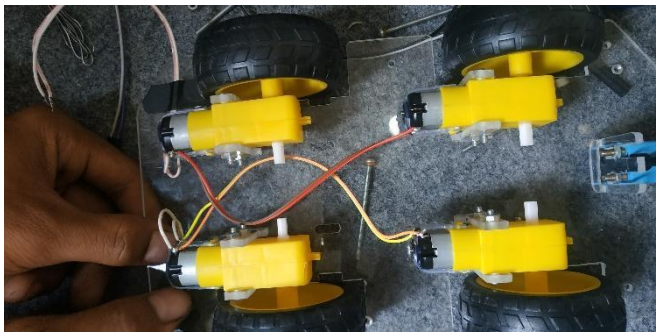

Figure 12. DC Motor Circuit

3) Robot control using smartphone android

The robot control circuit Bluetooth using smartphone android consists of a smartphone module Bluetooth, circuit Arduino UNO, motor driver L298N, and a DC motor. For more details, see **Figure 13**.

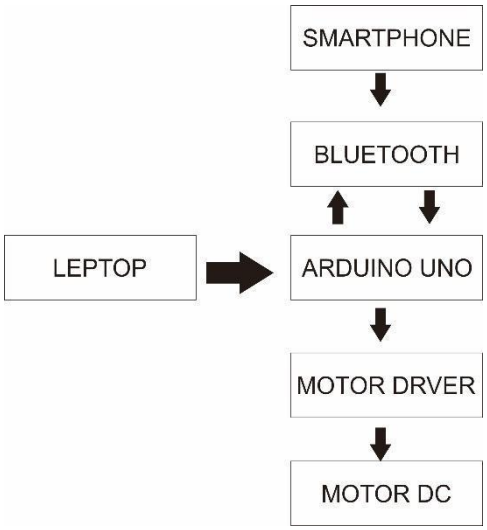

Figure 13. Robot control circuit

To get a robot control circuit Bluetooth with a smartphone, there is a need for a connection between the module Bluetooth and Arduino using cable a male-female jumper. What must be connected can be seen in **Figure 14**.

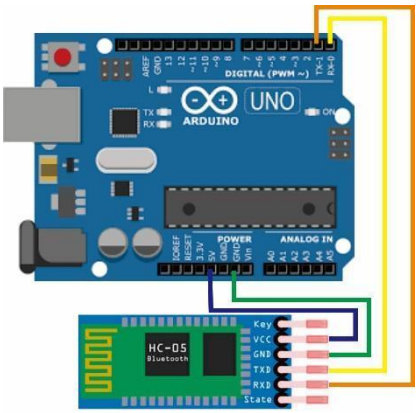

Figure 14. Bluetooth wiring on Arduino UNO

The principle of controlling a robot requires a smartphone android to control the direction of motion using an application system. Inside it has been given logic data that is sent via Bluetooth HC-05 and entered into the microcontroller system, namely Arduino UNO. Arduino works based on commands that have been programmed and provides data to the motor driver, then the DC motor will determine the direction of rotation.

The results of the analysis of robot control Bluetooth with a Smartphone Android-based on Arduino Uno, this robot uses the Arduino Uno as a robot control system Bluetooth Hc-05, where the command sent by the smartphone to be able to move the Dc motor so that it can move the Arduino-based robot that is made. The Arduino controller RC car is in **Figure 15** show, and the Arduino-based metal detector robot designed as shown in **Figure 16**.

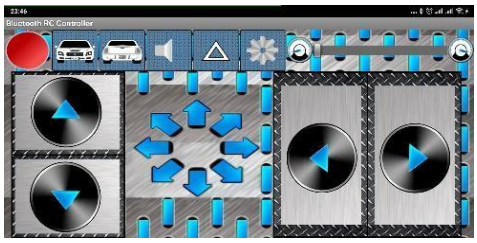

Figure 15. Arduino controller RC car

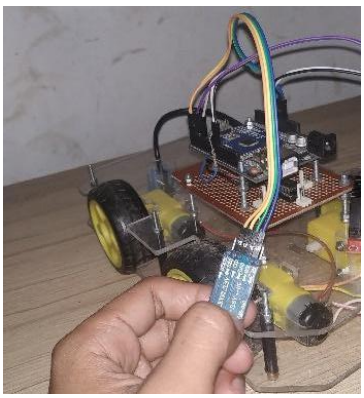

Figure 16. The result of an Arduino-based robot design

C. The Results of Testing Tool

1) Test results of metal detector

Testing the system input on the sensor connected to the microcontroller with output buzzer and LCD. The use of the buzzer is intended to determine the presence of detected metal, and the use of LCD as a display of the resulting voltage on each detected metal. The results of metal detector testing by placing metal above and below the ground areas in **Table 3** and **Table 4**.

TABLE 3. Metal detector test results (metal placed on the ground)

Metal Type	Distancae (cm)	**Buzzer**	
		On	**Off**
Aluminium	0,5	✔	
	1	✔	
	1,5		✔
Iron	0,5	✔	
	1	✔	
	1,5		✔
Copper	0,5	✔	
	1	✔	
	1,5		✔

TABLE 4. Metal detector test results (metal placed on the ground)

Metal Type	Distance (cm)	Buzzer	
		On	Off
Aluminium	0,5	✔	
	1	✔	
	1,5		✔
Iron	0,5	✔	
	1	✔	
	1,5		✔
Copper	0,5	✔	
	1	✔	
	1,5		✔

2) Test Results of Robot design

In this stage, testing the robot control. The robot runs when it is on a level place, without obstacles or obstacles, and on the ground with obstacles or without obstacles. This robot uses a DC motor as a driving wheel. This motor has a specification V supply 6V, 1100 rpm, current 1 A.

Figure 17. Reliability testing

This robot is given an incline to find out how strong the robot can climb. In Figure 17, the robot climbs on a flat plane of about 30 degrees with a PWM 160-255. In this condition, the robot can rise. **Table 6** below is the provision of PWM values for DC motors to determine which robot PWM values can pass a 30-degree incline.

TABLE 5. Results of testing the robot's strength at a slope of $30^{0.}$

Slope	PWM	Result
30^0	100	Not Moving

From the test results, it is known that the PWM value of 100 robots cannot increase. When testing the voltage of battery 7.4 V, the robot can climb on this slope.

IV. CONCLUSION

Metal detectors can detect the presence of metal with a variety of metal types, aluminum, low carbon steel, and copper with a maximum detection distance of 1 cm. The reliability of the robot can move with a terrain slope of 30^0, using a 7.4V DC motor, 160-255 rpm rotation.

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