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Robotic vehicle for Land Mine Detection and Isolation

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ABSTRACT:This paper proposes the implementation of landmine detection and isolation robotic vehicle. Landmines are very destructive objects of warfare, they can be a threat to human and animal lives if not isolated. The robotic vehicle in the implementation is controlled by an application in our mobile phones using Bluetooth technology. Hence, the system is operated from a safe distance and threat to life is minimum. The implementation uses a metal detector for detecting the landmine and it uses a robotic arm for picking up the landmine and it is transported toa safe location where it is disposed safely. The implementation is cost effective as it uses a microcontroller, motors for locomotion rather than using an engine. It is power efficient as the system is battery powered, this makes it environment friendly as fossil fuels are not used. This system can be employed by the military to save more lives for safe disposal of landmines in war areas.

KEYWORDS: Landmines, Metals, Robotic Vehicle, Robotic arm, Arduino, Proximity Sensor, Gripper

I.INTRODUCTION

Landmines have metal casing and they generally consist of a button on the top. The button when pushed detonates the landmine severely harming the individual who triggered it. The landmines are buried in such a way that the button on the top is exposed, the remaining part of the landmine body is buried under the soil. If a person looks at a piece of land which contains landmines at a distance he cannot tell whether there are landmines there are not. Hence, for isolation of such a destructive device its precise location has to be detected first. Since, the outer casing of a landmine is made up of metal a metal detector is used to detect the precise location of the landmine. The metal detector works on the principle of Faraday's laws of electromagnetism and the phenomenon of resonance. It consists of a buzzer which generates a sound when metal is detected. The mobility is provided to the implementation using DC motors which are controlled using the Arduino microcontroller. The robotic arm of pick and place type uses servomotors which are also controlled using Arduino microcontroller. The robotic arm in our implementation is a 2 degree of freedom robot arm.

The operator gives commands to the system through a mobile application having a simple user interface. The mode of communication employed for the transmission of commands to the implementation is Bluetooth. The Bluetooth module receives the commands and instructs the Arduino to process the command as per the code written performing the required function. The range of communication obtained was 7-10m.Metal objects were detected using one transmitting loop and two receiving loops. The eddy current produced in the metal object changed the magnetic field in the receiving coil and thus helped to detect the presence of metal object in presence of alternating magnetic field [13].

This method uses 2 receiving coils for detection of metallic objects. In the implementation, the metal detector circuit consists of only one coil in order to detect the presence of metal objects, thereby reducing complexity and materials

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used to implement it. The object assumed by them is to be spherical in shape, where as in our implementation, the circuit detects metallic objects of any shape.

Metal detector circuit implemented in this paper uses 555 Timer [7].One of the drawback mentioned in the paper was precise position and flexibility of the coil. Even small millimetre mistake in positioning of coil would tremendously affects the working of the detector circuit. In our implementation we overcame this challenge by use of potentiometer to adjust the range and working of metal detector circuit based on the position of the coil. In our system we have implemented the metal detector circuit using TDA 0161 which is an inductive type proximity sensor.

The paper helped us in design and implementation of the robotic arm which helps in isolation of land mine [6]. The survey described about the various parameters of robotic arm such as axis, degree of freedom, kinematics etc which helped in design and implementation of robotic arm. Pick and place robot design [12] is similar to the land mine detection robot apart from the fact that the pick and place robotic vehicle detects any object near the vehicle,whereas the land mine detecting vehicle differentiates metals with non-metallic objects using electromagnetic laws. The implementation in this paper was done using a PIC 16F877A microcontroller whereas Arduino was employed in the implementation of robotic vehicle and arm. Thus, making the system cost effective. This paper describes android application controlled Arduino based remote control car whose primary aim is to control the motion of the vehicle through an android application [1]. The implementation had employed a L293D motor driver to control DC motors. In the Landmine detection and isolation system uses an ADA Fruitshield which can be used to operate both DC motor and AC servo motors, enabling the complete implementation using single microcontroller.

The section 2 explains about design and the hardware realisation of the laser guitar system. The section 3 discussesthe complete implementation of the system along with the discussion of results obtained. Section 4 concludes the discussion on implementation. Section 5 discusses the scope for further development of the system.

II.SYSTEM DESIGN AND ANALYSIS

The overall block diagram and flowchart of the system is shown in figure 1 and figure 2. Initially the connection between Bluetooth module(HC-05) and mobile phone is established. Servo motors occupy their initial positions. Data received from the mobile application is processed by Arduino and required actions are performed. If the data commands the motion of the system then the DC motors are rotated according to the requirement.

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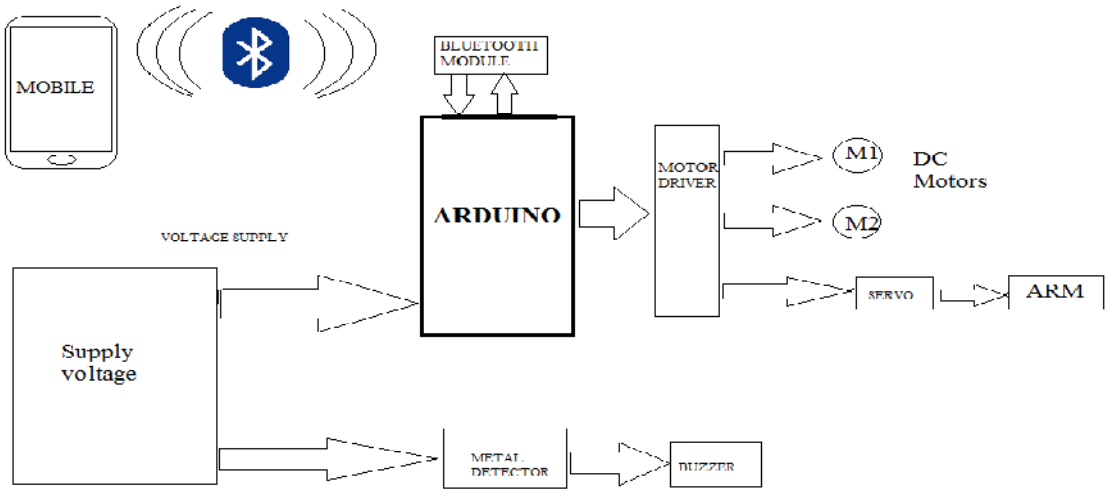

Fig. 1. Block Diagram of metal detector

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If the data received commands the system to collect the metal, then servo motors are controlled accordingly. These control signals are sent by the user through mobile application as per figure 2

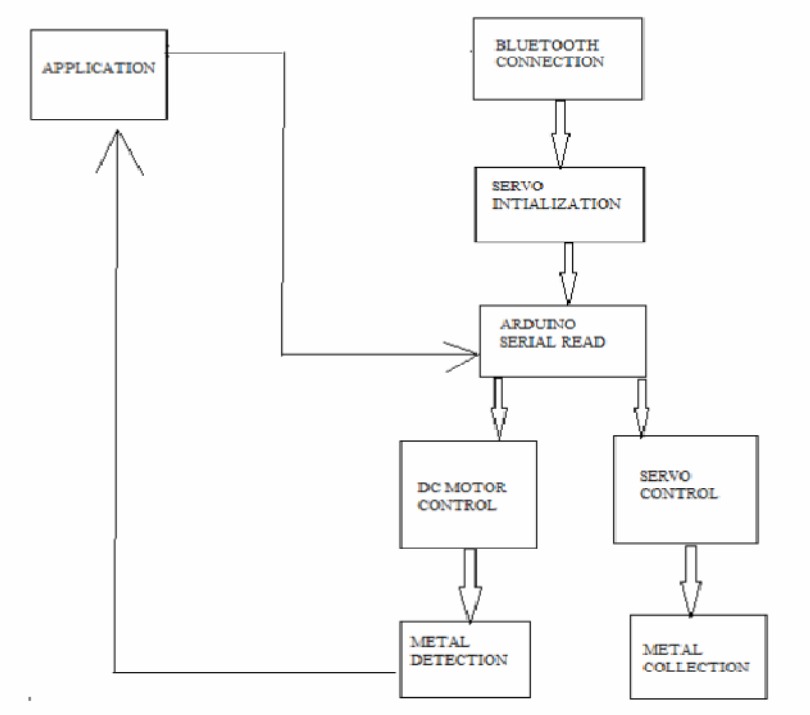

Fig. 2. Block Diagram of the implementation

The entire implementation can be divided into 2 parts which include the metal detector and the robot vehicle with robotic arm part. The block diagram of the metal detector part is shown in figure 3.The metal detector part uses a TDA0161 inductive type proximity sensor, a copper wire of 27-30 gauge wound into a coil of 5-6 cm with 175-185 turns, a 5 volt buzzer, a 2N222A npn transistor. The inductive type proximity sensor is used for non-contact detection of metallic objects. If the metal detector of contact type the coil may accidently push the button on top of the landmine which could detonate the landmine and compromise the system. Hence, inductive type proximity sensor is used. The proximity sensor, when the circuit is powered up produces behaves as an oscillator. This behaviour is aided by an externally tuned LC circuit where L is the inductance of the coil used and 47nF is the value of the capacitance to which the coil is connected in parallel. When the coil is not above a metal object the current output in the coil is 1 mA this current is not sufficient to turn on the 2N222A npn transistor, hence the buzzer will not produce sound. When the coil is directly above a metal object an electric field is created due to the phenomenon of resonance because of which the current in the coil increases to 10mA which is sufficient to turn on the transistor thereby turning on the buzzer.

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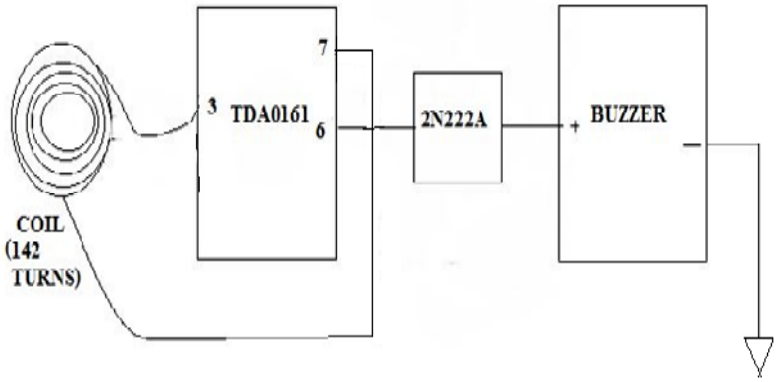

Fig. 3. Block Diagram of the metal detector

Eddy currents induced in the coil due to metal object determines the value of resistance Rp of the proximity sensor. If Rp is greater than the variable resistance R1 then current output is 1mA else it is 10mA. This variable resistor is used to tune the proximity sensor. The change in the current flow acts as the means for detecting the metal objects. The desired range of non-contact metal detection was considered to be 2 inches. The oscillator frequency for that range of non-contact detection was found to be dependent on the range and was determined to be around 19 kHz. It is shown in figure 4.

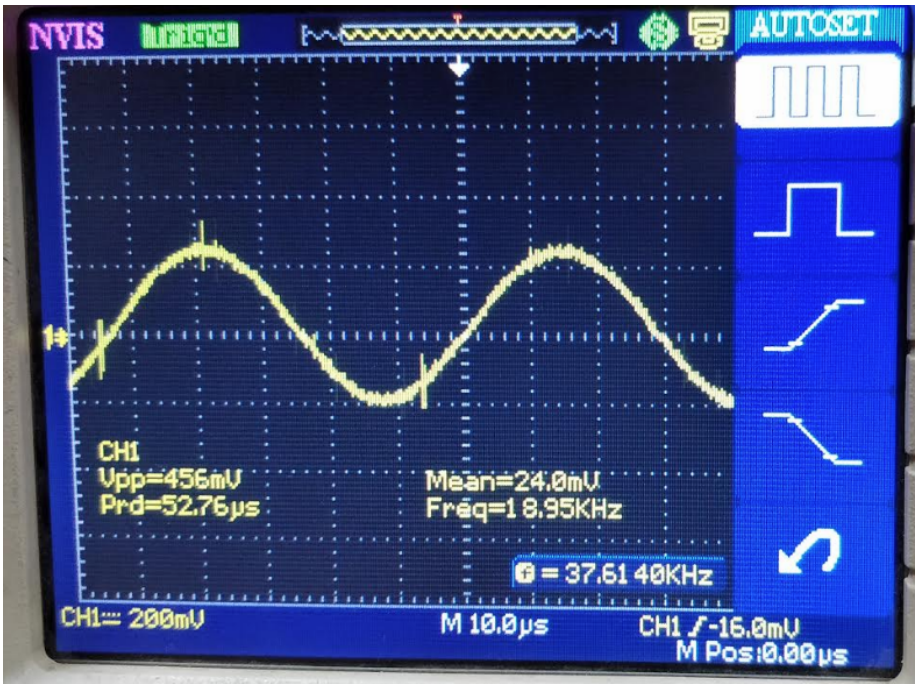

Fig. 4. Waveform when metal is not present

The inductance for the above range is calculated as follows:

$$L = ((\mu_r * turns^2 * area)/ length) * (1.26*10^{-6}) \quad (1)$$

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Where,

L = inductance of coil.
μ_r = relative permeability of core material (air =1)
turns = number of turns of coil.
area = the cross-sectional area of core in square metres.
length = length of coil in metres.

Inthe metal detector circuit, the value of inductance (L) for the oscillator frequency is 1504.99 μH.
Using the (1), the number of turns was calculated which was found to be 180 turns.

The block diagram of implementation of the robotic vehicle and robot arm is shown in figure 5.

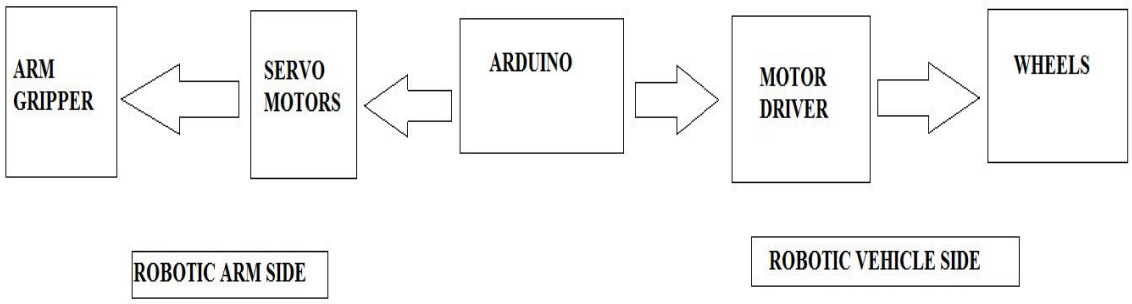

Fig. 5. Block Diagram of robotic arm and vehicle

A sturdy chassis was employed for the robotic vehicle. The chassis was selected such that it was capable of housing the metal detector circuit on it along with the robot arm gripper and also the microcontroller and batteries. The movement of the robot vehicle was realised using DC motors which were connected to the ADA fruit motor shield which acts as a motor driver generating sufficient torque for the movement of the entire system. A microcontroller was used to control the direction of rotation of the DC motors which control the direction of movement of the system. AC servo motors were used to realise the 2 degrees of freedom robot arm. AC servo motors were used as they can be used for low power applications and they provide high accuracy during pick and place of landmines, as landmines should be handled carefully because their detonation could compromise the system. Servo motors work on the principle of pulsewidth modulation. Pulses enable the controlling of servo motors according to the required positions or angles. A robot gripper having a smooth gear mechanism was chosen for proper functioning of the pick and place operation. 2 AC servo motors were employed to provide 2 degree of freedom. The ADA fruit motor shield was used in order to avoid damages to the microcontroller used. A single microcontroller was used to control both the robotic vehicle and robotic arm mechanism. The Bluetooth module was connected to the Arduino microcontroller. Bluetooth is used as the mode of communication between the device and the operator.

III. IMPLEMENTATION AND RESULT DISCUSSION

The proposed solution uses microcontroller to give mobility to the system and also to control the movement of robotic arm. The system uses Arduino Uno as microcontroller. Communication is done to the system using Bluetooth interface. Mobile based application is used to give commands to the system through Bluetooth module HC-05. As mentioned in the hardware design, the system comprises of motor driver (ADA Fruit) connected with Arduino Uno microcontroller that helps in controlling the mobility of the system through DC motors attached to it.The Arduino acts

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as the slave and the user interface of mobile application behaves as master in the system. The system can move in the forward, reverse, left, right, forward left, forward right directions. Mobile based application is used to issue the command for desired movement of the system through Bluetooth interface. Serial Communication is used in order to detect if the command is issued to system through mobile based application using command Serial read. The software implementation uses library module AF Motor which gives speed and direction control for DC motor driven by using ADA Fruit Motor Shield. Based on the value of the serial read, appropriate condition is invoked and the direction of the DC motors is controlled. The direction of rotation of the two motors is same during forward and backward movement. The left motor will rotate forward and right motor will rotate backwards for Left movement of system. The right motor will rotate forward and left motor will rotate backwards for Right movement of system. This way we give mobility to our system.

Robotic arm implementation:

We use robotic arm for isolation of land mines. The movement of robotic arm is done through Servo Motors attached to Arduino Uno through ADA Motor Shield. ADA motor shield can control up to 4 DC motors and 2 Servo Motors. Servo motor is a rotary actuator or a motor that allows for a precise control in terms of the angular position, acceleration and velocity. Servo motor works on the principle of PWM (Pulse Width Modulation) where the angle of rotation is controlled by the duration of pulse applied to it. As mentioned in hardware implementation, the robotic arm implemented can provide 2 degrees of freedom. To do this our system has two servo motors. The elbow servo provides movement from 0° to 180°. Gripper servo provides the movement which is used to pick and place the land mine. Using serial read, user issues the command to the system through mobile application. Based on the value of serial read, appropriate function is invoked to provide the movement of Elbow servo or Gripper servo using AF motor library module. So this way we can control the movement of the robotic arm in our system.

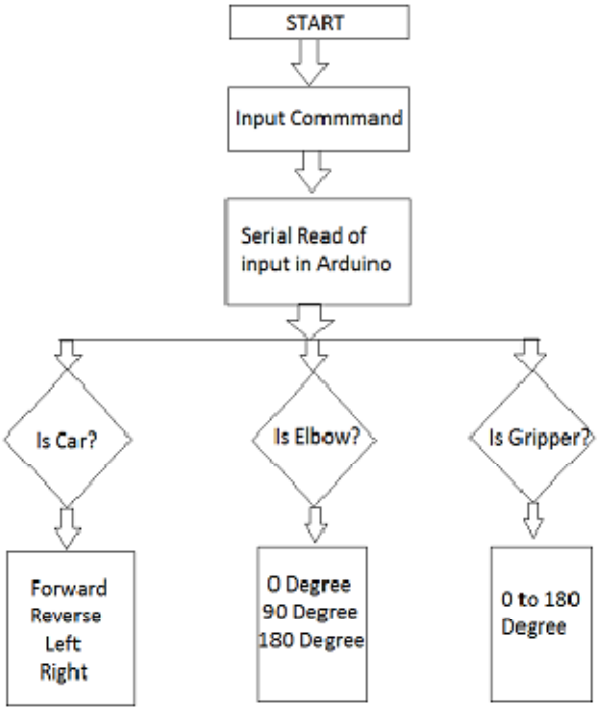

Fig.6.Arduino code flow

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The frequency when the metal is detected was measured using the CRO by connecting the probes across the coil terminals of metal detector. This frequency was measured to be in the range of 10-12MHz as shown in fig 7.The waveform is also shown in fig 7.

Fig.7. Waveform when metal is detected

IV.CONCLUSION

The implemented system successfully detected metal object buried in the earth. The system can detect metallic objects up to distance of 2 inches with high accuracy. The oscillator frequency when metal is detected was found to be 10-12 MHz due to resonance. Both robotic arm and robotic vehicle were successfully implemented using a single microcontroller. The implementation can easily pick and place land mines precisely. The system provides immediate response based on the command issued through mobile based application with negligible delay. The robotic vehicle in system is not driven using engine mechanism. The implementation is driven using battery power and thus uses no fossil fuels for mobility. Hence the system is environment friendly. The implemented system is cost effective and can be employed in military.

Figure 8 shows the final implementation which can successfully detect the metal bodies without contact with it and pick and place them in separate location. The user interface for controlling the robotic vehicle and arm is shown in fig 8.

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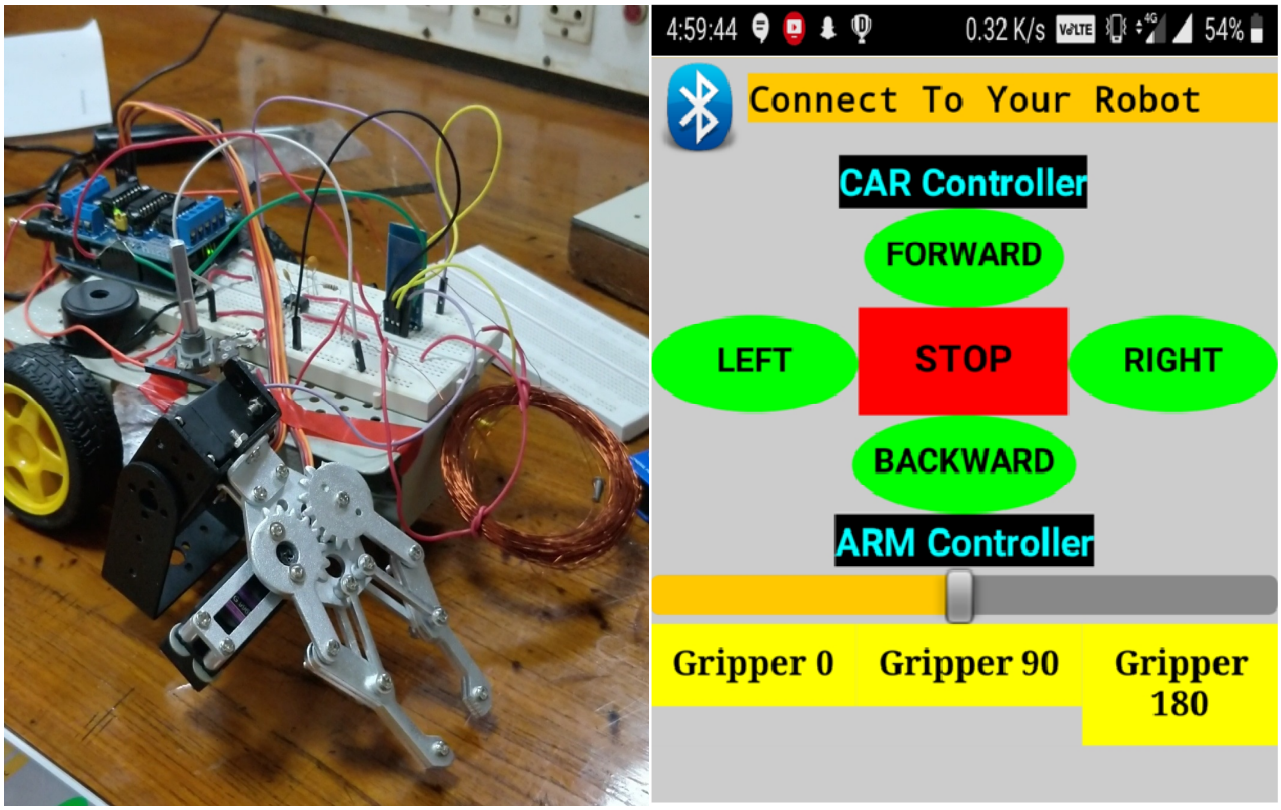

ig.8. Final implementation and user interface

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