Remote Area Clearance Device (RACE)

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1 Introduction

1.1 Objective

It is quite common for people to lose small metal objects around the house, at work, or at a lab. These objects can be hard to find because of their size, which is a problem as these objects can hold sentimental or monetary value, and can also pose a safety hazard to pets or small children.

Our proposed solution is to develop a robotic car that a user can control with a laptop or some other electronic device and can detect metal and retrieve these objects.

While our particular design for the robot is meant for indoor use, there are many other useful applications. Despite the United States having the world's largest army, IEDs and mines still pose significant difficulties for the Army with regard to engineering operations and maneuver support [1]. This robot can be used by bomb disposal teams to remotely identify and dispose of bombs. Bomb identification and disposal makes soldiers quite vulnerable, so having a semi-autonomous vehicle doing the searching for them would decrease the number of casualties. The United States Army Corps of Engineers has shown some interest in this project. They are interested in producing semi to fully autonomous vehicles to support army engineers, and have offered to provide our team with some of their robots and equipment.

1.2 Background

We wanted to build a robot metal detecting car that is easy to operate, and inexpensive. Operating hand held metal detectors can become quite finicky and demanding, when the scope search area is wide [2]. Additionally, while there are several high quality metal detectors used by bomb squads to search for landmines, they can be quite expensive.

While our robots targeted use is within labs and homes to look for small objects such as rings and needles, its use can be extended to open terrain, where it can be an inexpensive way to look for landmines.

1.3 High-Level Requirement List

- The metal detector must be able to detect small metal objects such as rings, nails etc., and notify the user through a speaker.
- The movement of the robot, including turns and acceleration must be able to be controlled though the laptop, with the signals transferred through Bluetooth.
- The retrieval unit must be able to pick up small objects, such as nails and rings regardless of their shape.

2 Design

2.1 Block Diagram

Our project requires five major units: namely a metal detection unit, a navigation unit, a power supply, a retrieval unit and a control module. The metal detection unit is used to detect metallic objects, and the retrieval unit enables the robot to pick up these objects. The control unit uses Bluetooth, so that the user can wirelessly control the navigation unit which operates the robot, and the retrieval unit. A power supply is needed to power these different modules.

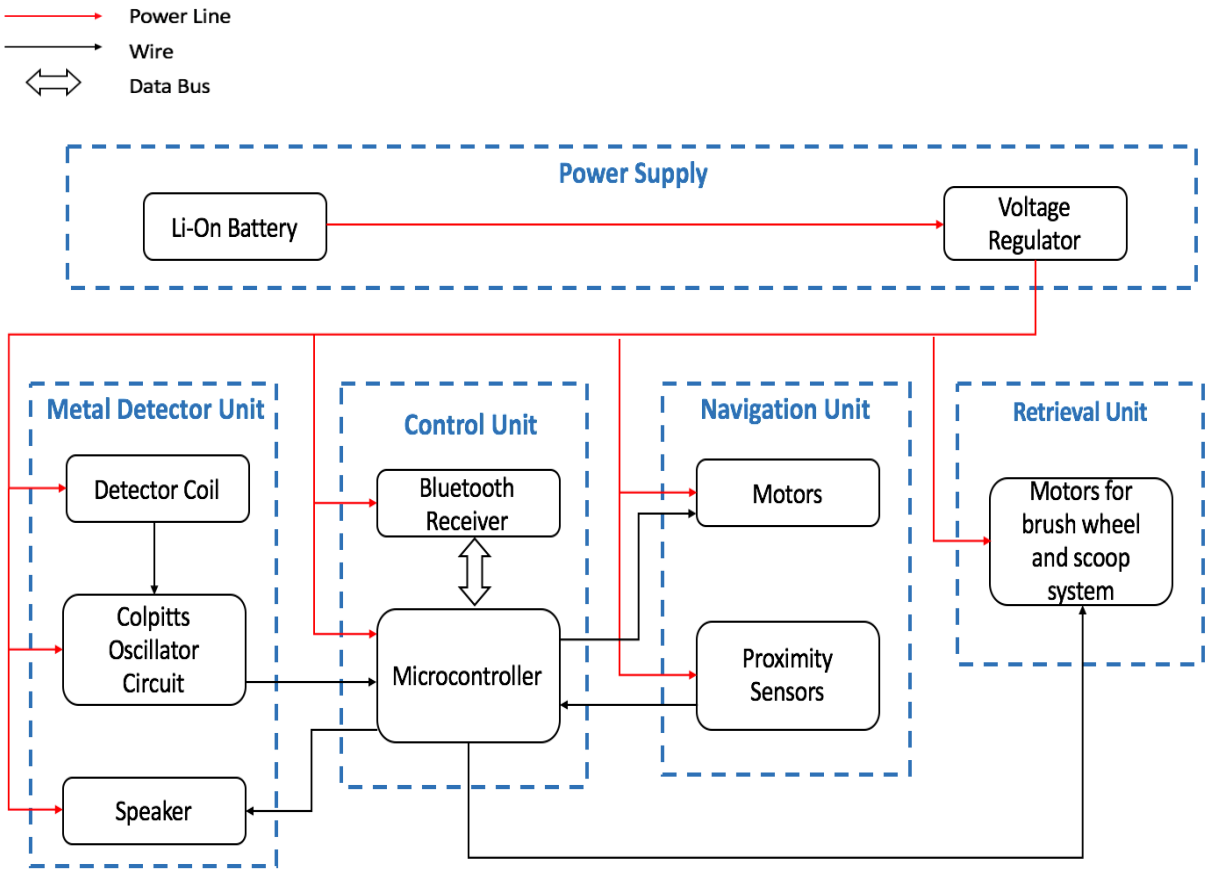

Figure 1: Block Diagram

2.2 Functional Overview and Block Requirements

2.2.1 Power Supply

A power supply is required to run the car, the metal detection circuit and the retrieval unit. Power will be regulated to 4.5V for the metal detection circuit, and for the motors for the car and retrieval system.

2.2.1.1 Li-On Battery

The battery must be able to keep all the modules continuously powered.

Requirement: Must be able to store enough charge to provide current at 5-6V.

2.2.1.2 Voltage Regulator

The voltage regulator is needed to keep the output voltage stable at 4.5V

Requirement 1: The regulator should provide 4.5V ± 5% from a 5-6V source.
Requirement 2: Must maintain temperature between operating range of under 125℃.

2.2.2 Metal detector Unit

The metal detector circuit is used to detect small metal objects, with the capability to notify the user through a speaker upon detection.

2.2.2.1 Detector Coil

The detector coil will be attached to the front of the robot car, so that it can scan the floor to look for metallic objects. To prevent the detector from getting confused by distant metallic objects that are not the target (such as chair legs), its range will be limited to 3-5 cm.

Requirement: The magnetic field area created by the inductor coil should be big enough to give it a range of 3-5 cm. To achieve this, it will be made from about 40 wraps of 26 AWG around a spool of 5 inches ± 20% in diameter. The number of wraps can be increased or decreased to give the detector the appropriate range [3].

2.2.2.2 Colpitts Oscillator Circuit

The Colpitts Oscillator circuit feeds the number of oscillations into the counter of the microcontroller [3]. Metal objects cause a fluctuation in this frequency [3]. A change above a threshold limit will trigger the speaker.

Requirement: The oscillator circuit must provide a steady oscillation in the 100kHz ± 5% range.

2.2.2.3 Speaker

The speaker will be used to notify the user when a metal object is detected.

Requirement: The buzzer must be loud enough to be heard across a distance of at least 30ft.

2.2.3 Navigation Unit

The navigation unit is used to control the movement of the car. It enables the user to accelerate, and turn the car left and right through a laptop.

2.2.3.1 Motors

The motors will be used to drive the wheels of the robot car.

Requirement: The motors must be able to operate at 4.5V±5%. They must be able to move the full weight of the car and the metal detector circuit.

2.2.3.2 Proximity Sensors

The proximity sensors will be used to look for objects in the front of the car to prevent collision. Upon detecting an object, the sensors will be output a high voltage, which will be fed to the microcontroller which will stop the motors.

Requirement: The proximity sensor must output a voltage of at least 4V upon the detection of an object in the range of 0-2cm, and a voltage less than 1V otherwise.

2.2.4 Retrieval Unit

The retrieval unit will be used to collect the object once it has been detected by the metal detector. It will be controlled by the user through the laptop.

2.2.4.1 Brush and Wheel Scoop System

A simple brush wheel and scoop system will be used, which will be driven by two motors.

Requirement 1: The system should be able to cover all the area under the detector.
Requirement 2: The system should be able to pick up small objects like rings, nails etc. regardless of their shape and weight.

2.2.5 Control Unit

The control unit consists of a Bluetooth module and a microcontroller. It will be used to control the operation of the robot car and the retrieval system.

2.2.5.1 Microcontroller

The microcontroller chip (ATMega328) communicates with the Bluetooth module. It allows for the operation of the car and the retrieval system, and to detect the change in frequency in the inductor of the metal detection circuit.

Requirement 1: The microcontroller must be able to communicate with the Bluetooth receiver over UART.
Requirement 2: The chip must be able to store a fixed frequency, and compare it with the incoming frequency of the detector coil.

2.2.5.2 Bluetooth Receiver

The Bluetooth receiver is used for wireless communication with the microcontroller. It enables the user to wirelessly control the car's navigation and the retrieval system from a distance.

Requirement: The receiver must have a range of at least 30 ft.

2.3 Risk Analysis

The working of the metal detection unit poses a challenge for our project. The circuit's range and placement should be accurate enough so that it can detect small objects and isolate their location to a small enough area so that they can be retrieved. At the same time, the detector should not trigger the speaker because of metallic objects that are not the intended target. We will have to calibrate the detector and store a fixed frequency. We will also have to experiment with the number of wraps and a sensitivity value in order to achieve this accuracy.

Another tricky part of our project is the retrieval unit. It needs to cover all ground where the object can possibly be, thus this module will work in conjunction with the navigation unit. Additionally, the unit needs to be able to retrieve small objects, regardless of their weight and shape. This is one of the reasons we chose a brush wheel and scoop system, as opposed to a vacuum pump or an electromagnet.

3 Ethics and Safety

One of the ethical challenges posed by our project is the way it is used. Since it is a robot car that can be controlled wirelessly, a potential issue of trespassing property arises. The IEEE Code of Ethics states that one should avoid to injure other people and their property [4]. Further, since the car does not have a camera, it could also possibly injure people if it is not in the sight of the user during operation. To prevent the misuse of this robot, we have decided to use a Bluetooth receiver with limited range. In order to prevent possible injuries to people and damage to property, we will use motors that limit the speed of the car, since the aspect of speed is not very important for our project. Further, we use proximity sensors, which will shut off the motors automatically when an object is detected nearby, to prevent injuries and damage to property.

The car will use lithium ion batteries, which pose a potential safety hazard. To prevent the batteries from moving around during the operation of the car, they will be securely placed on the chassis of the car. Even though the recommended use of the product is indoors, all electrical components will be covered and no wires will be left exposed in order to prevent water damage from causing short circuits.

We are also responsible for being honest about the claims we make about the project [4]. To adhere to this guideline, we will be very careful about the suggested usage of our product. Until it can meet the minimum accuracy guidelines for detecting landmines, the suggested usage would be strictly for home and recreational use.

The IEEE Code also states that one must hold paramount the safety of the public [4]. We believe that we are making an excellent cost effective platform, that can possibly help people in war torn

regions. While it's suggested use is in homes, its features can be expanded as the product is a great platform.

References

[1] Siegel, R. (2002). *Land mine detection - IEEE Journals & Magazine*. [online] Ieeexplore.ieee.org. Available at: http://ieeexplore.ieee.org/document/1048979/ [Accessed 6 Feb. 2018].

[2] Ishak, H., Kadir, H., Lim Chain Fat and Mohd Helmy Abd Wahab (2008). Autonomous metal detector robot with monitoring system. *2008 International Symposium on Information Technology*.

[3] Le Mentec, F. (2016). *Metal detection: beat frequency oscillator*. [online] Embeddedrelated.com. Available at: https://www.embeddedrelated.com/showarticle/911.php [Accessed 8 Feb. 2018].

[4] Ieee.org, "IEEE Code of Ethics", 2018. [Online]. Available: http://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed 07 Feb. 2018].