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Autonomous Navigation of a Robotic Metal Detector

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ABSTRACT: A practical and simplified approach is applied to the implementation of an Autonomous Robotic Metal Detector (ARMED). The literature gives detailed information of the basic concepts and design strategies used to design the metal detector. The Robot is controlled by a microcontroller. Infra-red sensors detect the presence of objects and the microcontroller activates the required search algorithm to detect the metallic property of the metal sensed. The metal detector makes use of a Colpitts Oscillator design to detect metals.

KEYWORDS: Colpitts Oscillator, Microcontroller, Metal Detector, Algorithm, Obstacle Avoidance.

1 INTRODUCTION

In the 21st century the impact of robotics has left a significant impact in the day to day affairs of man. The robotic metal detector is no exception, as it makes use of basic principles of robotics to detect metals without any human control. This form of metal detection is very important due to its effectiveness as compared to later forms of metal detection techniques which are manually operated and very slow in carrying out metal detection effectively. Robot controlled metal detectors play important roles in detecting land mines and metals in airports, sea ports, banks, etc.

The design of the robotic metal detector involved the application of microprocessor based programming to provide a more effective form of metal detection; various microprocessors were studied in order to narrow down a simpler, economical and more flexible microprocessor to meet with the challenging task. The robot was designed to be adaptive to reprograming in order to fit into various tasks depending on the nature of the task in question. In the design of the program, the sequence of operation of the metal detector was simplified to reduce system complexity.

2 PROBLEM STATEMENT

The ability to sense for the property of metals in objects has been a great challenge in engineering. Various objects as well as destructive devices such as landmines, improvised Explosive Devices (IEDs) etc. In space exploration, where human inhabitation is almost impossible, robotic systems are capable of executing such detection and observatory routines.

3 PREVIOUS WORK

In early days of metal detection, *Hughes et al* demonstrated a manually operated induction balance metal detector. It purpose was to study the metallic structure of metals and alloys.

A more advanced approach developed in later years adapted a robot controlled metal/mine detection robot (RCMD). This approach quantitatively addressed the relationship between the detection performance and controlling the gap and attitude of the sensor head to the ground surface. The RCMD adapted 3-D high speed mapping of the ground surface and can generate trajectories of the sensor head with 3-D stereovision camera and Laser camera. Image processing algorithms were applied for vegetation recognition. The controlled object of this approach is called Controlled Metal Detector (CMD). It consists of the two-coil metal detector and a 3-DOF mechanical manipulation mechanism driven by electric motors.

4 Proposed Approach

The design makes use of a single and robust microcontroller 16f84A. The robot comprises of four geared stepper motors to provide easy navigation. A Colpitts oscillator is integrated in to the robot for metal detection. The design was developed to showcase an easy yet effective approach for metal detection to enhance academic research and real-time simulation of test scenarios. This approach compared to other methods proved to be economical yet effective for small/medium scale metal detection.

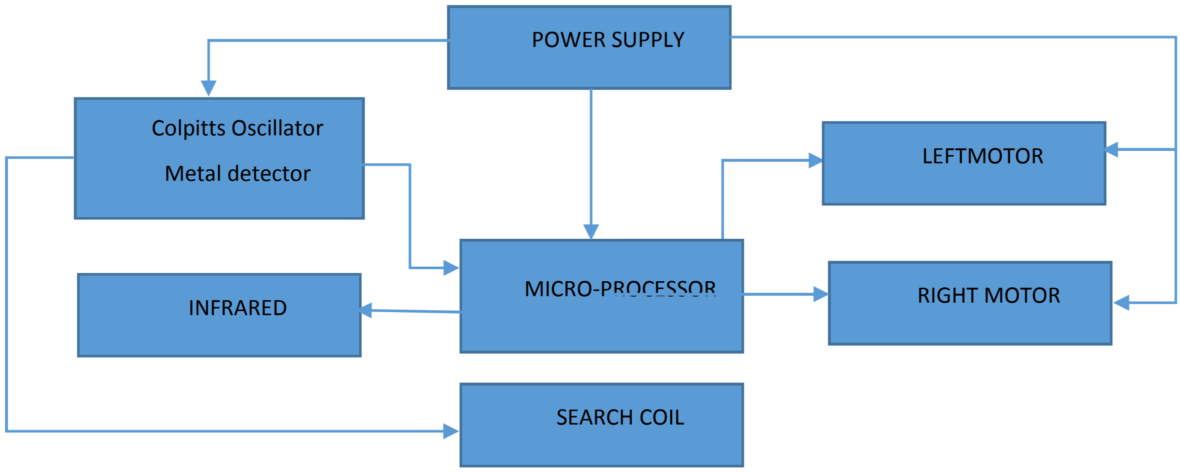


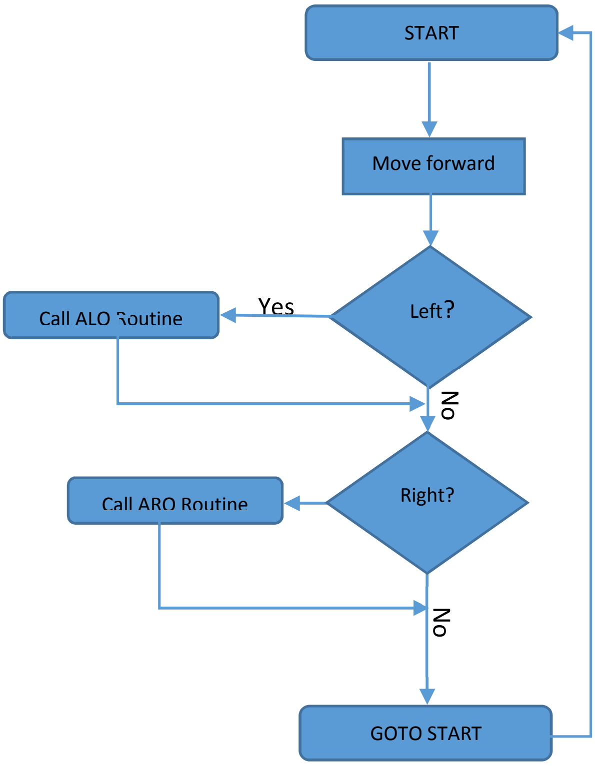
Fig 1.0. The Proposed System block diagram

5 Automation And Control Algorithm

The Autonomous Robotic Metal Detector (ARMED) is controlled by an obstacle avoidance algorithm that responds to signals from an array of infrared detectors. The signals from the sensors are used to initiate various routines to approach an object, detect the metallic property of objects along its path and finally assumes another orientation for further detection.

The three routines are divided into three main algorithms (Avoid Left Obstacle [ALO], Avoid Right Obstacle [ARO] and Metal Detection Routine [MDR]) that caters for 180 degrees object avoidance routine and metal detector drive control.

AUTONOMOUS CONTROL ROUTINE FLOW CHART



Main Control Program Snippet

```
Scan Infrared ports {
 If (object == left)
             Call ALO routine () {
 Start MDR ()
             }
else
 Call ARO routine () {
            Start MDR ();
                                   }
end;

}
```

Fig 2.0 (a) Flow chart diagram of Robot Search routine (b) Control code snippet

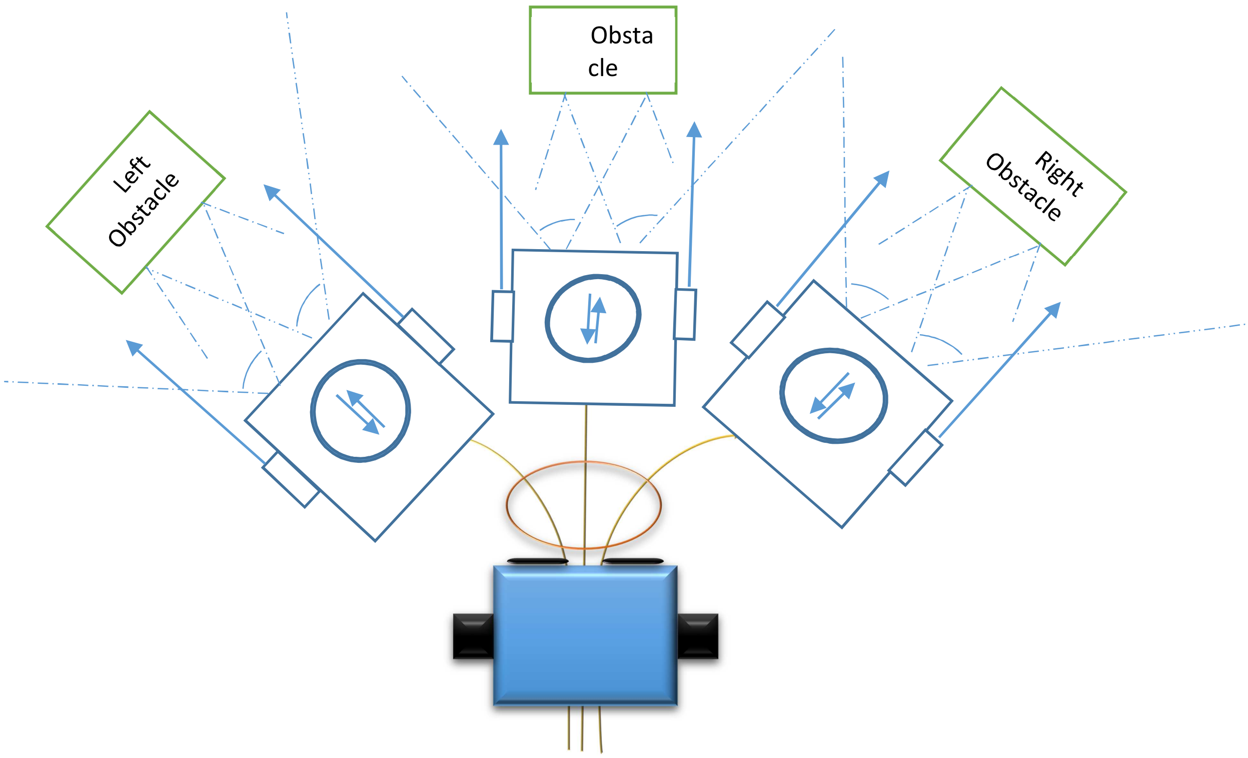


Fig 3.0 Robot Multi directional Search path

6 OBSTACLE AVOIDANCE BEHAVIOR

The obstacle avoidance detector comprises of an infrared transmitter and receiver, the infra-red transmitter was designed to oscillate at about 36 kHz (at this frequency, the infrared receiver is able to detect infra-red rays). The obstacle avoidance feature of the robot alerts the microprocessor of the presence of an object of considerable distance of about 5 – 20cm. The infrared sensors are constantly at a high state (logic I), in the situation where an object is detected, the rays are reflected back to the sensor which sends a low signal to microprocessor, at the reception of the signal, the micro-processor executes the appropriate obstacle avoidance routine as illustrated in the block diagram.

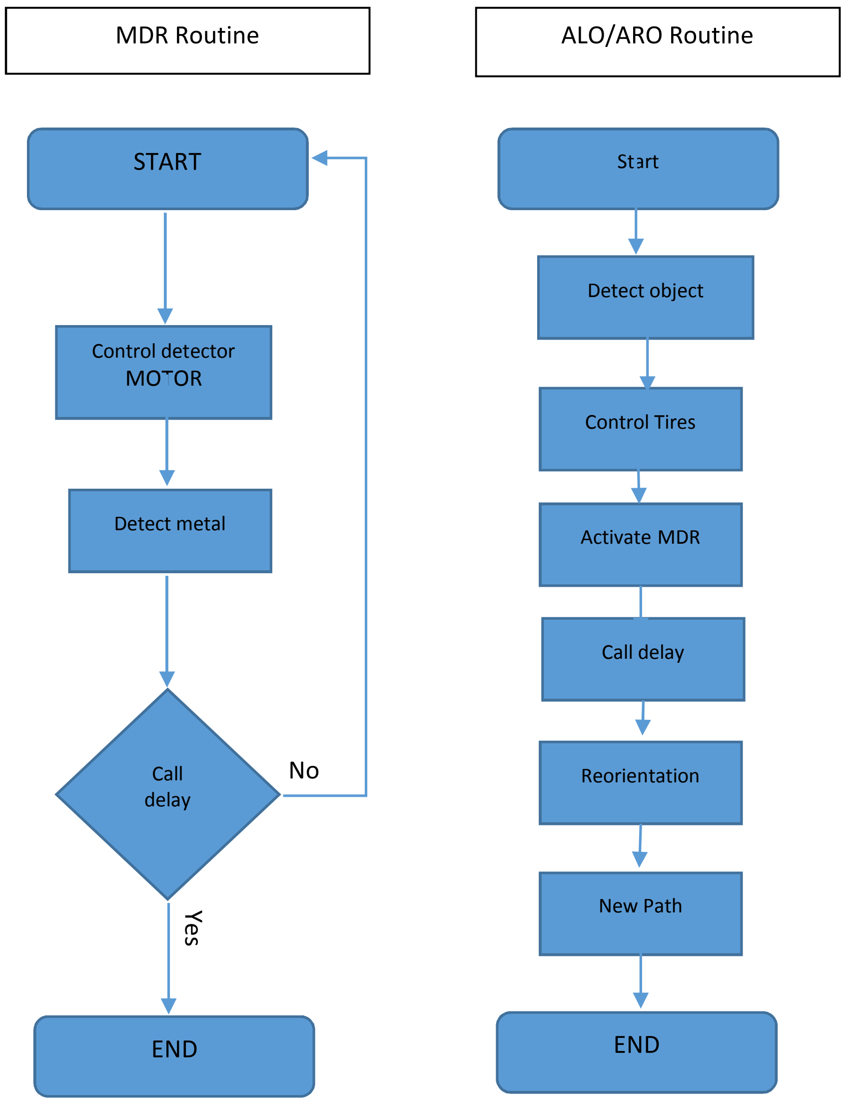


Fig 4.0 (a) Metal Detection routine (b) Obstacle Avoidance and Coil search routine

7 METAL DETECTOR

The metal detector comprises of two Colpitts oscillator coupled together to a two stage amplifier. Both oscillators are tuned to oscillate at similar frequency of about 110 – 160 kHz. One of the coils is formed into a *circular loop* of about 8 – 12 cm while the other coil of the oscillator is onboard the circuit panel in a smaller diameter loop of about 1 – 2 cm. The coil with the wider loop acts as the searching (detector) coil to be controlled by the robot for metal detection. When the detector coil is place over any material with metallic properties, the frequency of the oscillators drops significantly, so as to cause an imbalance in the circuit. The difference in the frequency alters the tone of a speaker or beeper connected to a two stage amplifier.

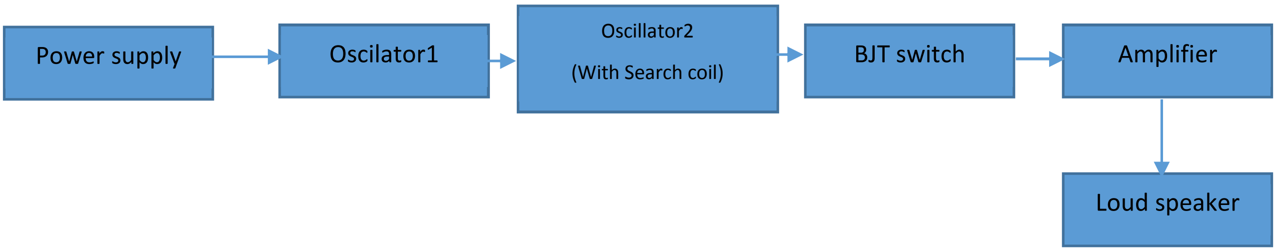


Fig 5.0 Metal detector block diagram [4]

7.1 COLPITTS OSCILLATOR

The Colpitts oscillator is an LC oscillator that can be implemented in two main configurations; common-base and common collector [3]. As earlier stated, the oscillator is unique because of its simplicity and robustness.

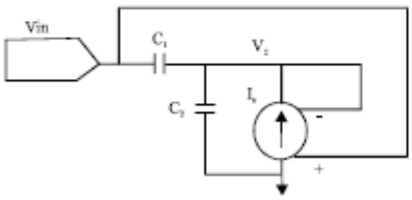


Fig 6.0 Colpitts Oscillator Model [3]

Eliminating all other elements, the Ideal frequency of oscillation is:

$$f_0 = \frac{1}{2\pi\sqrt{L\frac{C_1C_2}{C_1+C_2}}}$$

The input impedance is written as:

$$Z_{in} = \frac{V_1}{I_2}$$

V_i Is given as:

$$V_2 = I_2Z_2$$

Z_2 Is the impedance ofC_2. The current flowing intoC_2. Is I_2, which the sum of two currents I_2

$$I_2 = I_1 + I_2$$

Where I_s is the current supplied by the transistor I_s is a dependent current source, as shown below

$$I_s = g_m(V_1 - V_2)$$

g_m Is the Trans conductance of the transistor. The input current is written as:

$$I_s = (V_1 - V_2)/Z_1$$

Where Z is the impedance of c2, solving for V1 and substituting above yields:

$$Z_{in} = Z_1 + Z_2 + g_mZ_1Z_2$$

The input impedance appears as the two capacitors in series with an interesting term, R_{in} which is proportional to the product of the two impedances, R_{in} = $g_mZ_1Z_2$and in cases where Z_1 and Z_2 are complex R_{in} becomes:

$$R_{in} = \frac{-g_m}{w_2C_1C_2}$$

8 CONCLUSION

The design and implementation of the Autonomous Robotic Metal Detector has proven to be a very important tool in the detection of metallic properties in materials. The ease at which it operates has also given the robot a very flexible approach to metal detection. As such, the robotic metal detector can be easily integrated to serve other purposes such as an obstacle avoidance robot and also for laboratory tutor purposes. Its flexibility feature is due to the fact that all the components of the robot were made in very simple modules that can easily be dismantled and reconfigured to meet the designer's specifications. The design also re-emphasizes the importance of robotic systems in solving complex tasks. Hence, robotic engineering is of paramount importance in the 21^{st} century to meet growing challenges that requires an inter-disciplinary approach.

REFERENCES

[1] Fumiya Lida "Goal-Directed Navigation of an Autonomous Flying Robot" AI Lab, Department of Information Technology, University Zurich Winterthurerstr. 190, CH-8057 Zurich, Switzerland.

[2] T.R. Neumann, S.A. Huber, H.H. Bulthoff. "Minimalistic Approach to 3D Obstacle Avoidance Behavior from simulated Evolution" Proceedings of 7th International Conference on Artificial Neural Networks, ICANN '97, W.Gerstner et al. (Eds), pp. 715 – 720, 1997.

[3] TA.M.O. Obiazi et al. "Implementing a Robust Metal Detector Utilizing the Colpitts Oscillator with Torodial Coil" Journal of Engineering and Applied Sciences 5(2): 56-63, 2010

[4] ESSEX Metal Detectors "Beat Frequency Oscillator Metal Detector (BFO)". [Online] Available: http://www.easytreasure.co.uk/bfo.htm (2008).

[5] Brown, C.L, et al. "Landmine Detection using single sensor metal detectors". Proceedings of the IEEE international Conference on Acoustics, Speech and Signal Processing, May 13 - 17 IEEE Xplore, London pp. IV -2948-IV3951.

[6] A-Medina Santiago et al. "Programming Real-Time Control Robot Prototype". Journal of Applied Research and Technology, pp. 927 -931.

[7] Rafael K. Pearson Education "Motion Control of Robot Manipulators". 1st edition, Ed. Pearson Education.

[8] Lajara V. et al. "Graphical Environment for programming". Alfaomega marcombo, Colonia del Valle, 2007.

[9] Asakawa et al. "Metal Detector for tracing submarine telecommunication cables". IEEE Tran. Instrumentation Measurement. 32: pp. 477-483.

[10] Noor Emafazreen. "Design of a Pedal Walker Robot" Universiti Teknikal Malaysia Melaka, April 2008.