The Autonomous Metal Distinguisher

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Abstract

In this project, an autonomous metal differentiating robot was built. This robot has the capability to detect land mines and bombs on the battlefield, and can save many lives. Currently, metal detectors exist that can differentiate between metal objects and nonmetal objects. This robot was designed to differentiate among the metal objects themselves. The robot was tested using metal and nonmetal objects. It was programmed in PBASIC to detect objects with the infrared sensors and metals with the inductive sensor. A conductivity sensor was used to differentiate between objects which give off electrical conductivity and objects which do not. The robot was able to emit a preprogrammed sound through the speaker and display the names of the different metals on the LCD Panel. The Basic Stamp II was programmed to detect various metal objects. The robot was capable of differentiating between metals and nonmetals and identifying various metal objects.

Introduction

A minefield can be a large problem for security, and an advantage to terrorists. As stated in the article, Terrorists Threat To Human Life In Nepal1, minefields are more destructive and common than we think. Most mines are triggered unintentionally. Since the function of a mine is to explode under the slightest touch or pressure, and mines are hidden from human civilian view, many mines planted during past wars are still being triggered, as reported on how stuff works. Searching a mine field for unexploded mines is a very dangerous job and usually ends in casualties.

The purpose of the Autonomous Metal Distinguisher is to seek out and identify mines, grenades, and bombs without the use of humans. It works by first using infrared sensors to navigate through a room, then once an obstacle is encountered the robot uses an inductive sensor to determine whether or not the object is made of metal. If the object is not made of metal, the robot will keep on going, however, if it is made of metal the robot uses a conductive sensor to check the conductivity of the metal and indicate the type of metal that was found. The type of metal is displayed on the Serial LCD and a sound is emitted in accordance with the type of metal.

The Autonomous Metal Distinguisher would help relieve the risk encountered on a minefield, but there are many other applications such as airport or subway security. However, there is still future research to be done before the Autonomous Metal Distinguisher can go unmanned.

Methodology

One of the first steps in constructing the Autonomous Metal Detector was building the chassis. Before building the chassis a blueprint was sketched depicting the shape and dimensions of the robot. The entire chassis was made from precisely cut pieces of Plexiglas, which were glued together. Next the two main servomotors, which move the robot, were attached to precut slots in the chassis. Then the inductive sensor (metal detector) was attached to the front of the robot in order for it to differentiate between metal and non-metal objects. The Breadboard, which holds all of the robot's circuitry, was attached along with the infrared sensors. This helps the robot navigate around obstacles.

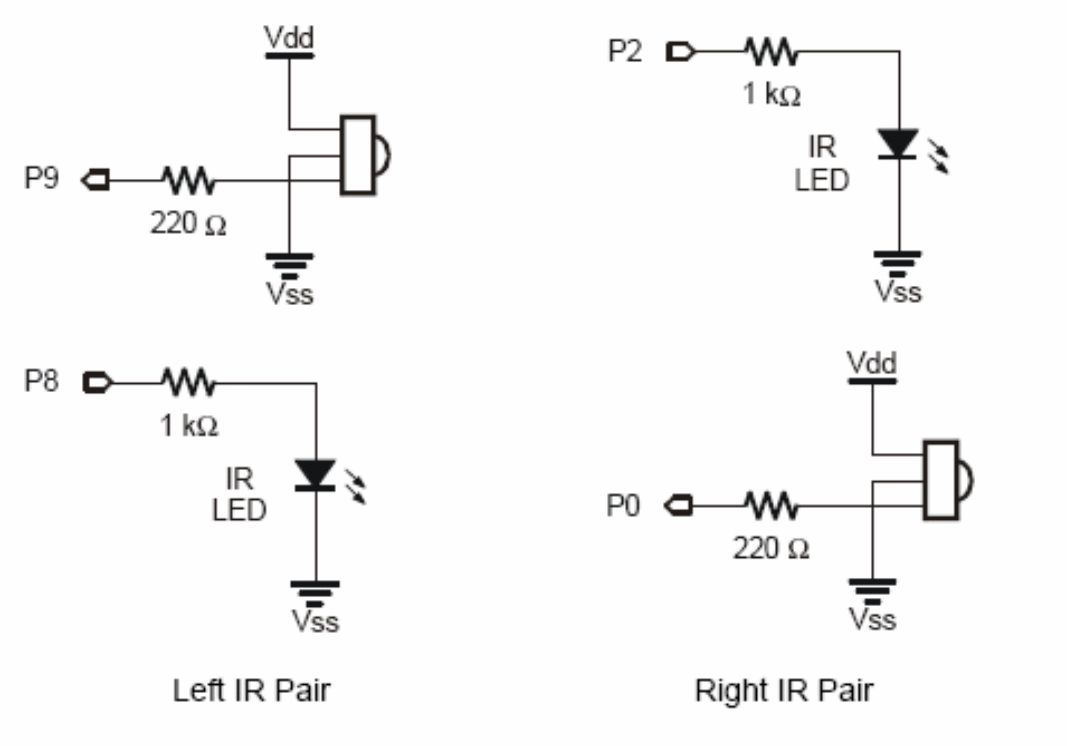
A later step to constructing the robot involved attaching the BASIC Stamp, which serves as a micro-controller (or mini central processing unit) and stores all of the robots programming while giving it commands. Also during this step the LCD (Liquid Crystal Display) screen was attached near the BASIC Stamp. The LCD screen serves the purpose of displaying the names of the metals that are detected.

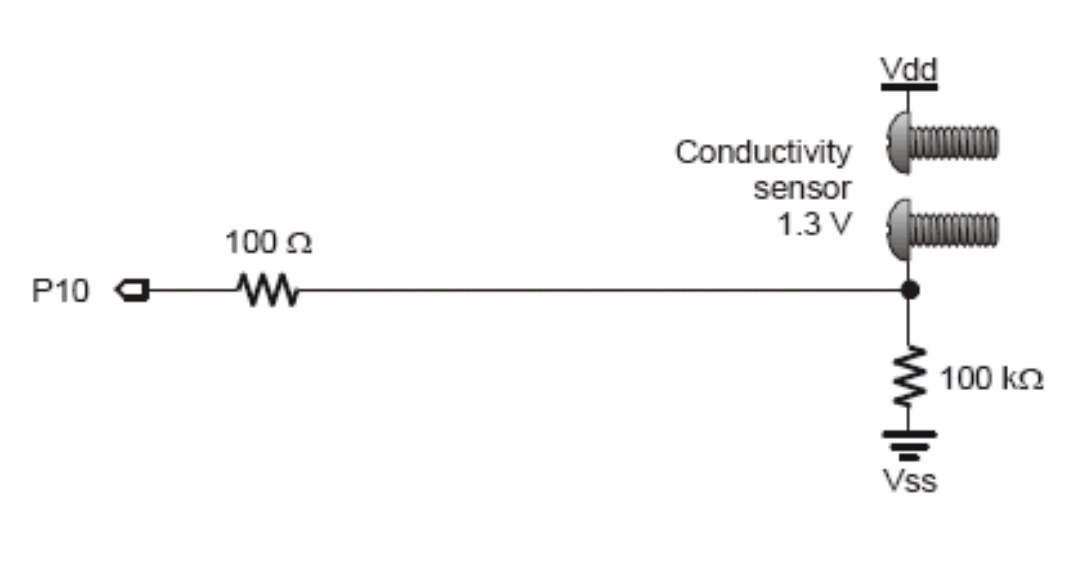
The final steps to constructing the robot included adding a third servomotor to the robot, which powers a descending arm that holds a conductivity sensor. The conductivity sensor is used by the robot to differentiate between different types of metals like copper, aluminum, iron, etc. After the construction of the robot was complete the circuitry was then wired to connect all the functioning parts to the BASIC Stamp so they can be sufficiently powered and controlled.

Following the wiring of the robot's circuitry the programming was written in PBASIC computer language. The infrared sensors were programmed to detect objects within the robot's environment. When the infrared sensors detected an object the robot moved towards the object. Using the inductive sensor the robot tested whether the object was metal or not. If the object tested to be a metal then the conductivity sensor tested the metal's conductivity and identified what kind of metal it was. The LCD screen was also programmed to display the name of the metal once the conductivity sensor had identified the metal.

The robot's servomotors were programmed to move the robot in various directions according to what the infrared and inductive sensors detected. This allowed the robot to cover a wide area of the environment searching for and identifying metal objects. The final programming was uploaded to the BASIC Stamp (through a serial cable) and saved to the BASIC Stamp's memory. This was the final piece to the puzzle in bringing about the Autonomous Metal Detector.

Schematics





Programming Code

```
' {$STAMP BS2}
' {$PBASIC 2.5}

counter VAR Byte
```

```
l_values VAR Byte
r_values VAR Byte
m_values VAR Byte
IR_freq VAR Word
n VAR Word
x VAR Word

metal VAR Byte

'--Initialization

n = 0

OUTPUT 1
OUTPUT 3
OUTPUT 5
INPUT 8
OUTPUT 9
TxPin CON 10
Baud19200 CON 32
main:
  l_values = 0
  r_values = 0
  m_values = 0

  GOSUB IR_navigation

  ' Forward navigation routine - if nothing is detected
```

```
  forward:
    PULSOUT 0, 850
    PULSOUT 1, 645

    ' Keep the robot in our range
    n = n + 1
    IF n > 200 THEN
      n = 0
      IF NCD(m_values) > 0 THEN main
      GOSUB half_turn
      FOR x = 1 TO 50
        PULSOUT 0, 850
        PULSOUT 1, 645
        GOSUB IR_navigation
      NEXT
      GOSUB half_turn
    ENDIF
GOTO main

' -----Navigation routines-----

' Turn left by one pulse
left_turn:
  PULSOUT 6, 640
  PULSOUT 7, 645
GOTO main

' Turn right by one pulse
```

```
right_turn:
  PULSOUT 6, 800
  PULSOUT 7, 865
GOTO main



' Stop moving
dontmove:
  metal = 0
  n = 0 ' Reset counter
  ' Move towards the object a little more
  FOR x = 1 TO 100
    PULSOUT 6, 775
    PULSOUT 7, 725
    PAUSE 20
    metal = metal + IN8     ' Check the material while moving towards
object
  NEXT


  ' Stop after getting close enough
  PULSOUT 6, 750
  PULSOUT 7, 755


  ' Detect the objects material


  metal = metal + IN8
  IF metal <> 0 THEN
    FREQOUT 9, 2000, 4000   ' Beep if it senses metal
  'ELSE
```

```
   ' FREQOUT 9, 2000, 100 ' Beep twice for non-metals

  ENDIF

  metal = metal + IN8

  IF metal <> 0 THEN

HIGH TxPin ' Set pin high to be a serial port
PAUSE 100 ' Pause for Serial LCD to initialize
SEROUT TxPin, Baud19200, ["Metal"]

  GOSUB turn_away

GOTO main


' Move away from objects that have already been detected

turn_away:

  GOSUB backward

  FOR x = 1 TO 50

    PULSOUT 6, 800

    PULSOUT 7, 865

    PAUSE 20

  NEXT

RETURN


' Back up a small amount

backward:

  FOR x = 1 TO 15

    PULSOUT 6, 640

    PULSOUT 7, 865

    PAUSE 20

  NEXT

RETURN


' Make a small turn to allow robot
```

```
' to come back at an angle
half_turn:
  FOR x = 1 TO 25
    PULSOUT 6, 800
    PULSOUT 7, 865
    PAUSE 20
  NEXT
RETURN

' -----IR Navigation Subroutine-----

IR_navigation:

  ' Zoning: Emit different frequencies to detect
  '         how far away the object is
  FOR counter = 0 TO 4
    LOOKUP counter,[37500,38250,39500,40500,41500],IR_freq

    FREQOUT 3, 1, IR_freq            ' Middle sensor detection
    m_values.LOWBIT(counter) = ~IN6

    FREQOUT 2, 1, IR_freq             ' Right sensor detection
    r_values.LOWBIT(counter) = ~IN5
    FREQOUT 4, 1, IR_freq             ' Left sensor detection
    l_values.LOWBIT(counter) = ~IN7
  NEXT
  ' Stop if it's close to the middle, or turn a pulse
  ' in the direction of the object
```

```
  IF NCD(m_values) = 5 THEN dontmove

  IF NCD(l_values) > 0 THEN left_turn

  IF NCD(r_values) > 0 THEN right_turn

RETURN
```

Data

Object	Electrical Conductivity
Aluminum	376.676 1/mohm-cm
Copper	595.8 1/mohm-cm
Iron	102.987 1/mohm-cm
Wood	0 1/mohm-cm

Discussion

Our goal was reached. We did make an unmanned metal detector. The results showed that our robot knew it was touching a metal because of the inductive sensor and so it displayed the word "METAL" on the Serial LCD. As of now the first response, and other bomb response teams are using weak manned or even hand held metal detectors when searching for grenades and/or mines. If the steps in the future are taken we could develop a stronger, better, more efficient robot.

Conclusion

The robot was successfully able to detect metal objects and distinguish among various metals using an inductive sensor and conductivity probe. Although the conductivity sensor was successfully able to test electrical conductivity, it was very weak and a stronger one would make this robot more efficient.

References

Terrorists Threat To Human Life In Nepal (Kamala Sarup, Wed Aug 10 2005, www.pressbox.co.uk)

How Landmines Work (www.howstuffworks.com/landmine.htm, Bonsor, Kevin)