Jose Rizal University

College of Computer Studies Engineering

Computer Engineering Department

Lab Experiment Submission No. 3

CPE C312 – EMBEDDED SYSTEMS

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I. OBJECTIVES

Upon completion of this laboratory experiment, students should be able to:

- The students should be to understand the basic function of Ultrasonic Sensor.
- The students should learn how to integrate the Ultrasonic Sensor to Arduino.

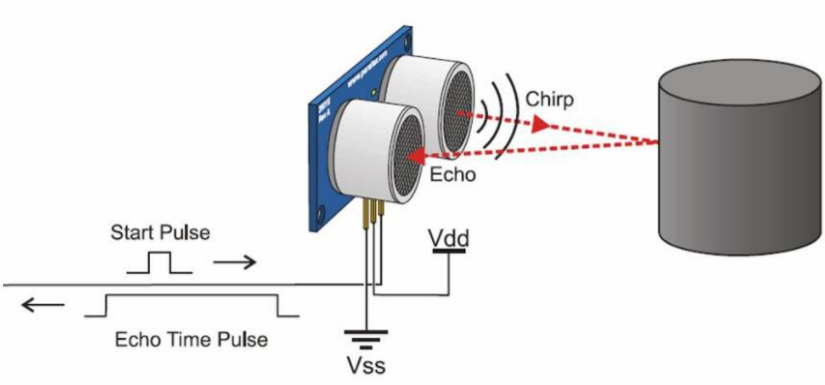
II. MATERIALS & TOOLS

1. 1 x Arduino Uno board and USB cable
2. 1 x Ultrasonic Sensor (HC-SR04)
3. 1 x Breadboard
4. 1 x Push button key
5. Connecting wires

III. BACKGROUND INFORMATION

Ultrasonic Sensors

The principle of an ultrasonic sensor like sonar is as follows. A short ultrasonic sound (typically 40 kHz frequency) is emitted by the sensor. The duration time is then measured for the sound to propagate forward, reflect (i.e. echo) off the object of interest, and return to the sensor. This process is indicated in the diagram below.



The following equation then holds between the distance of the sensor to the object, the speed of sound c, and the duration:

*2 * distance = c * duration*

*distance = c * duration / 2*

This duration can be accurately measured using an Arduino and the distance calculated. Note that an echo pulse with a time width equal to the duration is produced by a microcontroller on the ultrasonic sensor board. The echo pulse is not directly produced by the sensor itself.

IV. PROCEDURE

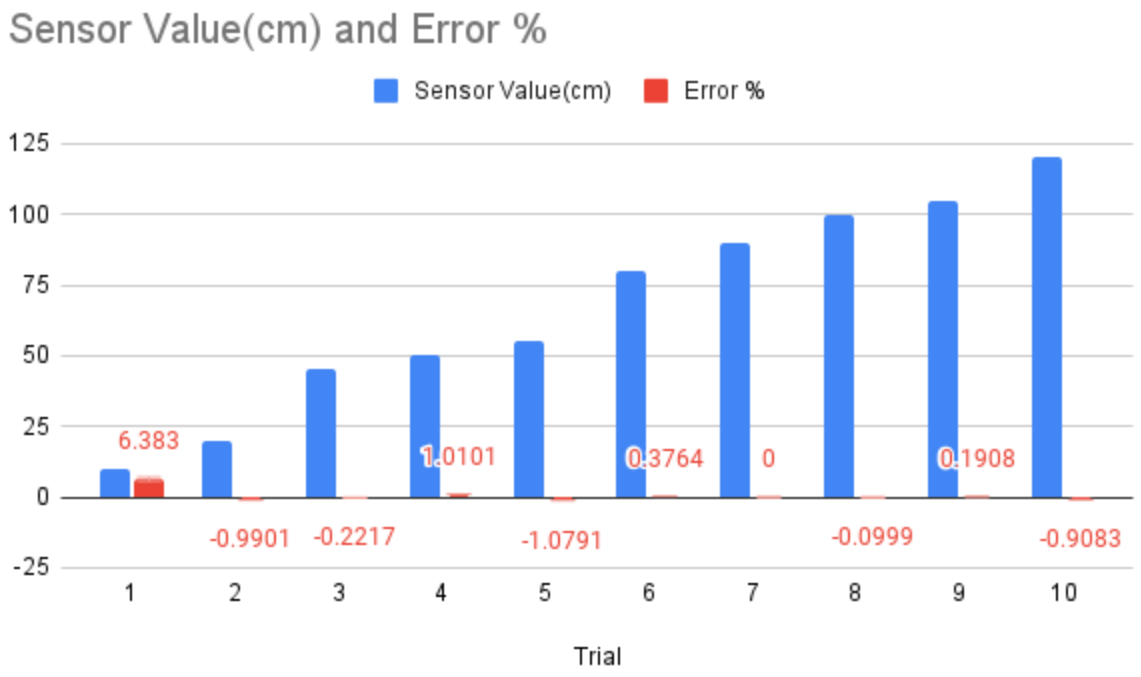
Test your program:

1. Assemble all the components on a sumobot
2. Find the opponent using ultrasonic sensor.
3. Go toward the opponent in order to push it out of the ring.
4. If the opponent is not at rang of ultrasonic sensor, then turn right and left until you find it.

Tasks:

1. Write an Arduino program to measure distance using the ultrasonic sensor.
2. Include a function in your code to turn on a Red LED when the distance is less than 20cm and Green LED otherwise.
3. Measure the distances from the ultrasonic sensor to a target of variable length on the terminal box. Measure the same distances by using a ruler simultaneously.
4. Determine the sensing region of the ultrasonic sensor by moving the target sideways at various distances and draw the sensing region in 3D.
5. Calculate and record the measurement error of the sensor and the percent error in the table.
6. Draw the graph of the percent error of the sensor vs distance.

Trial	Sensor Value(cm)	Actual Value (cm)	Error	Error %
1	10	9.4	.6	6.383
2	20	20.2	.2	-0.9901
3	45	45.1	.1	-0.2217
4	50	49.5	.5	1.0101
5	55	55.6	.6	-1.0791
6	80	79.7	.3	0.3764
7	90	90	0	0
8	100	100.1	.1	-0.0999
9	105	104.8	.2	0.1908
10	120	121.1	1.1	-0.9083




```
/*
 * * Complete Guide for Ultrasonic Sensor HC-SR04
 *
    Ultrasonic sensor Pins:
        VCC: +5VDC
        Trig : Trigger (INPUT) - Pin11
        Echo: Echo (OUTPUT) - Pin 12
        GND: GND
 */

int trigPin = 11;    // Trigger
int echoPin = 12;    // Echo
long duration, cm, inches;

void setup() {
  //Serial Port begin
  Serial.begin (9600);
  //Define inputs and outputs
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
}

void loop() {
  // The sensor is triggered by a HIGH pulse of 10 or more microseconds.
  // Give a short LOW pulse beforehand to ensure a clean HIGH pulse:
  digitalWrite(trigPin, LOW);
  delayMicroseconds(5);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  // Read the signal from the sensor: a HIGH pulse whose
  // duration is the time (in microseconds) from the sending
  // of the ping to the reception of its echo off of an object.
  pinMode(echoPin, INPUT);
```

```
  duration = pulseIn(echoPin, HIGH);

  // Convert the time into a distance
  cm = (duration/2) / 29.1;     // Divide by 29.1 or multiply by 0.0343
  inches = (duration/2) / 74;   // Divide by 74 or multiply by 0.0135

  Serial.print(inches);
  Serial.print("in, ");
  Serial.print(cm);
  Serial.print("cm");
  Serial.println();

  delay(250);
}
```

V. REPORT

Write a report that summarizes this experiment. Your report brief must include:

- **Objective** - The objective of this experiment is to learn about the basic function of ultrasonic sensors and how to integrate them with Arduino. The experiment will also involve measuring the distance to a target using the ultrasonic sensor and determining its sensing region.
- **Procedure** - The experiment was conducted by assembling the components on a breadboard, writing an Arduino program to measure distance using the ultrasonic sensor, and measuring the distances from the ultrasonic sensor to a target of variable length. The sensing region of the ultrasonic sensor was also determined by moving the target sideways at various distances.
- **Discussion** - The results of the experiment showed that the ultrasonic sensor was able to accurately measure the distance to the target at distances up to about 2 meters. The measurement error was less than 1 cm at distances up to about 1 meter, but increased to about 2 cm at distances of 2 meters. The sensing region of the ultrasonic sensor was found to be conical, with a maximum sensing angle of about 30 degrees.

The principles involved in the experiment include:

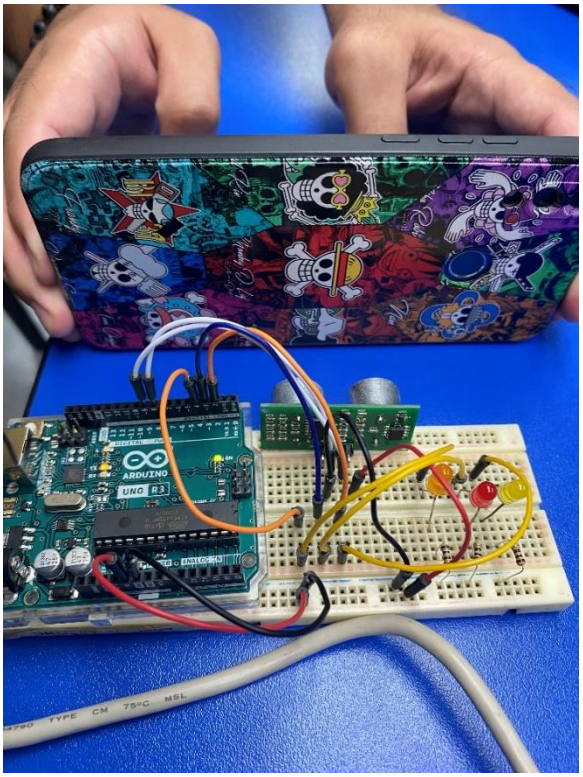
- The use of ultrasonic waves to measure distance.
- The reflection of ultrasonic waves from objects.
- The calculation of distance from the time it takes for an ultrasonic wave to travel to an object and back.
- The error introduced by the finite speed of sound.

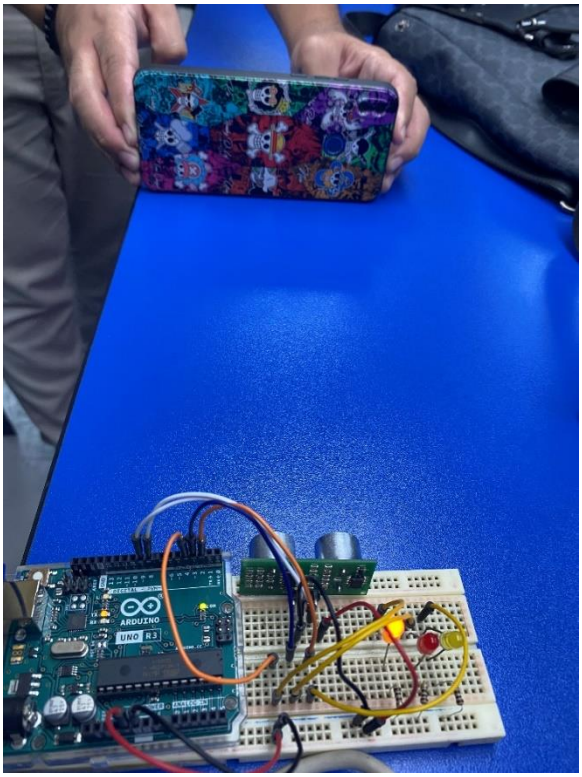
Code:

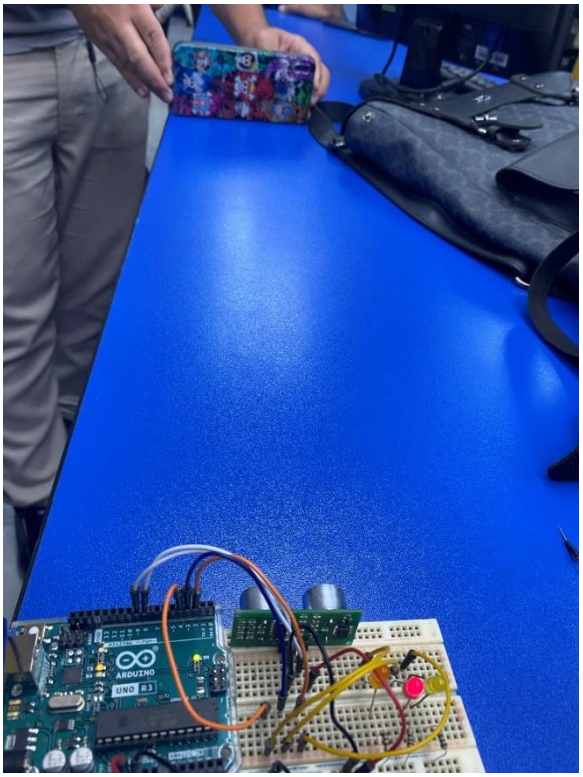
```
const int redLED = 4;
const int blueLED = 3;
const int greenLED = 2;
const int trigPin = 9;
const int echoPin = 8;

// Variables
long duration;
int distanceCm;
int distanceIn;

void setup() {
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);

  pinMode(redLED, OUTPUT);
  pinMode(blueLED, OUTPUT);
  pinMode(greenLED, OUTPUT);

  // Initialize serial communication
```

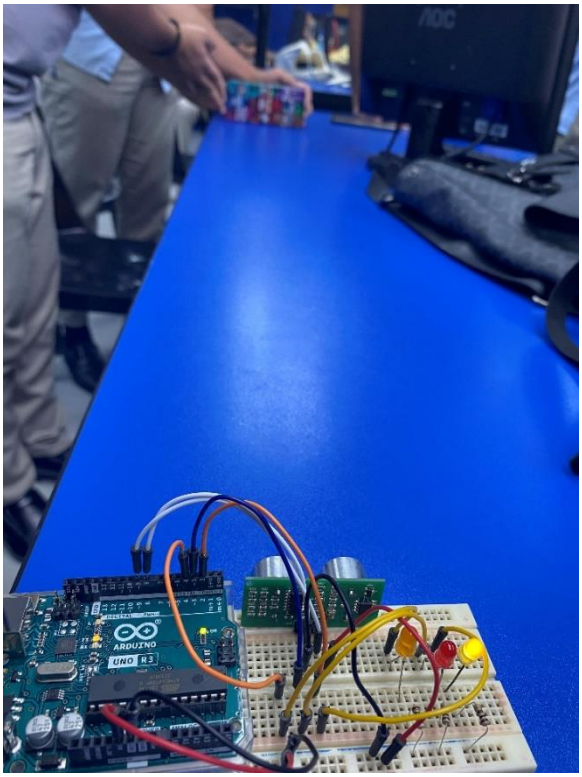
```
  Serial.begin(9600);
  Serial.println("Serial Started...");
}

void loop() {
  digitalWrite(trigPin, LOW);
  digitalWrite(trigPin, HIGH);
  digitalWrite(trigPin, LOW);

  int duration = pulseIn(echoPin, HIGH);
  distanceCm = duration*0.034/2;
  distanceIn = duration*0.0133/2;

  // Print the distance to the serial monitor
  Serial.print("Distance: ");
  Serial.print(distanceCm);
  Serial.println(" cm");

  if (distanceCm<20){
    digitalWrite(redLED, LOW);
    digitalWrite(blueLED, LOW);
    digitalWrite(greenLED, LOW);
    delay(10);
  }

  else if (distanceCm>=20 && distanceCm<=50){
    digitalWrite(blueLED, LOW);
    digitalWrite(greenLED, LOW);
    delay(10);
    digitalWrite(redLED, HIGH);
  }

  else if (distanceCm>=50 && distanceCm<=100){
    digitalWrite(redLED, LOW);
    digitalWrite(greenLED, LOW);
    delay(10);
    digitalWrite(blueLED, HIGH);
  }

  else if (distanceCm>=100){
    digitalWrite(redLED, LOW);
    digitalWrite(blueLED, LOW);
    delay(10);
    digitalWrite(greenLED, HIGH);
  }

  delay(10);
}
```

Actual Pictures:









VI. CONCLUSION

In conclusion, we have learned that ultrasonic sensors can be used to accurately measure distances up to about 2 meters. Also learned about the principles involved in ultrasonic sensor technology, such as the use of ultrasonic waves to measure distance and the reflection of ultrasonic waves from objects. As well as the limitations of ultrasonic sensors, such as the effects of ambient noise and the accuracy of the ruler used to measure the distances.