Practical Robotics Projects with Arduino

(CSE 4571)

Lab Assignment No – 04

ULTRASONIC & IR SENSING

Submission Date: _____

Branch: CSE		**Section:**
Name	**Registration No.**	**Signature**

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Aim:

Ultrasonic & IR Sensing – To Interface HC-SR04 and IR sensors with Arduino UNO for distance measurement and obstacle detection.

Objectives:

1) **To study the working principle of Ultrasonic (HC-SR04) and Infrared (IR) sensors.**
2) **To interface HC-SR04 ultrasonic sensor with Arduino UNO for distance measurement and display the output values on I2C LCD.**
3) **To interface IR sensor with Arduino Uno for obstacle detection using buzzer and LED.**
4) **To validate distance measurement of HC-SR04 ultrasonic sensor using LEDs as indicators.**

Answers to Pre-Lab Questions

A. Experiment-Specific

1. What is the working principle of the HC-SR04 ultrasonic sensor for distance measurement?
2. Mention the function of Trigger pin and Echo pin in the HC-SR04 sensor.
3. Write the formula to calculate distance from the ultrasonic sensor using the speed of sound.
4. What is the typical range of distance measured by an HC-SR04 ultrasonic sensor?
5. What is the working principle of an Infrared (IR) sensor used for obstacle detection?
6. Differentiate between active IR sensor and passive IR sensor with examples.
7. State any two applications of ultrasonic sensors in real life.
8. Why is it necessary to use pinMode() and digitalWrite() functions in Arduino while interfacing sensors?
9. How does an IR sensor distinguish between the presence and absence of an obstacle?
10. Mention one key advantage and one limitation of ultrasonic sensors compared to IR sensors?

Components/Equipment Required:

Sl. No.	Name of the Component / Equipment	Specification	Quantity
1)	Arduino UNO R3	16MHz	1
2)	Arduino UNO cable	USB Type A to Micro-B	1
3)	Ultrasonic sensor HC-SR04		1
4)	IR sensor module	Obstacle detection	1
5)	I2C LCD		1
6)	Buzzer		1
7)	Resistors (carbon type)	220Ω / 330Ω	2
8)	LED	Any colour of your choice	8
9)	Breadboard	840 Tie points	1
10)	Jumper Wire	----------	As per requirement

Objective 2

To interface HC-SR04 ultrasonic sensor with Arduino UNO for distance measurement and display the output values on I2C LCD.

Circuit / Schematic Diagram

Figure 1: *HC-SR04 Ultrasonic Sensor Pinout*

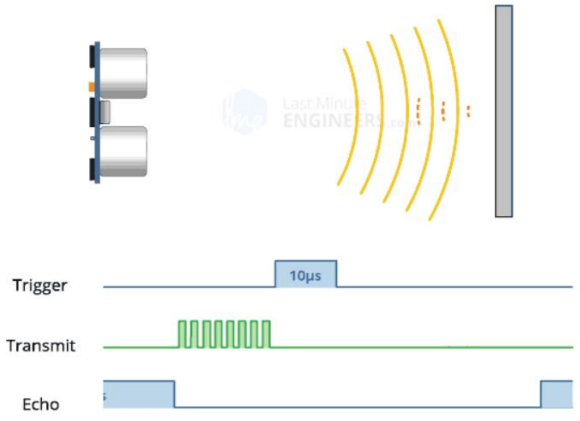

Figure 2: *Work of HC-SR04*

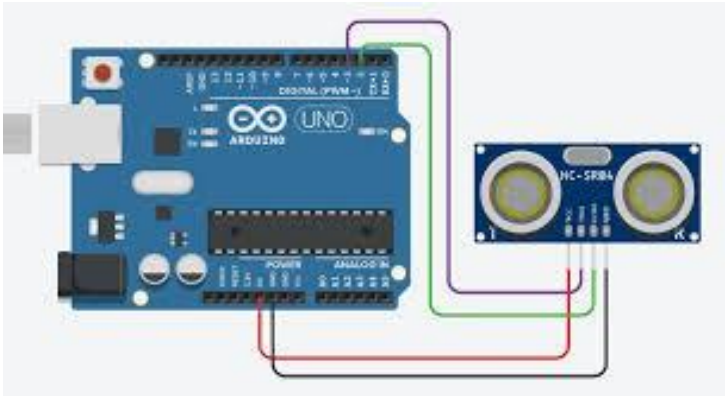

Figure 3: *Ultrasonic Distance measurement circuit using HC-SR04 & Arduino Uno*

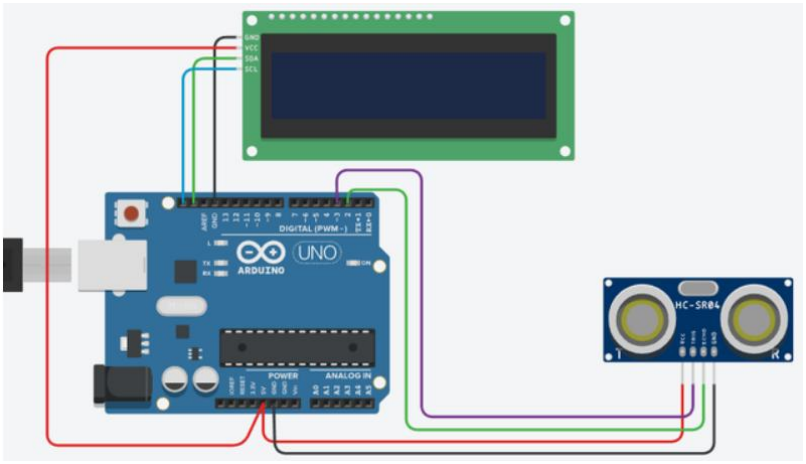

Figure 4: *Ultrasonic Distance Measurement Output in LCD Display*

Code

Write an Arduino program to interface HC-SR04 ultrasonic sensor with Arduino Uno for distance measurement and display the output value in I2C LCD.

```
#include <Wire.h>

#include <LiquidCrystal_I2C.h>

#define trigPin 9

#define echoPin 10

LiquidCrystal_I2C lcd(0x27, 16, 2);  // I2C address 0x27, adjust if needed

void setup() {

 lcd.init();

 lcd.backlight();

 pinMode(trigPin, OUTPUT);
```

```
  pinMode(echoPin, INPUT);
  lcd.setCursor(0, 0);
  lcd.print("Distance Meter");
  delay(1000);
  lcd.clear();
}

void loop() {
  long duration;
  float distance;
  // Send a 10µs pulse to trigger pin
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
// Read echo pin and calculate distance
  duration = pulseIn(echoPin, HIGH);
  distance = duration * 0.0343 / 2; // cm
 // Handle out-of-range
  if (distance > 400 || distance < 2) {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Out of range");
  } else {
    lcd.clear();
```

```
  lcd.setCursor(0, 0);
  lcd.print("Distance:");
  lcd.setCursor(0, 1);
  lcd.print(distance, 1);
  lcd.print(" cm");
 }
delay(500); }
```

Observation

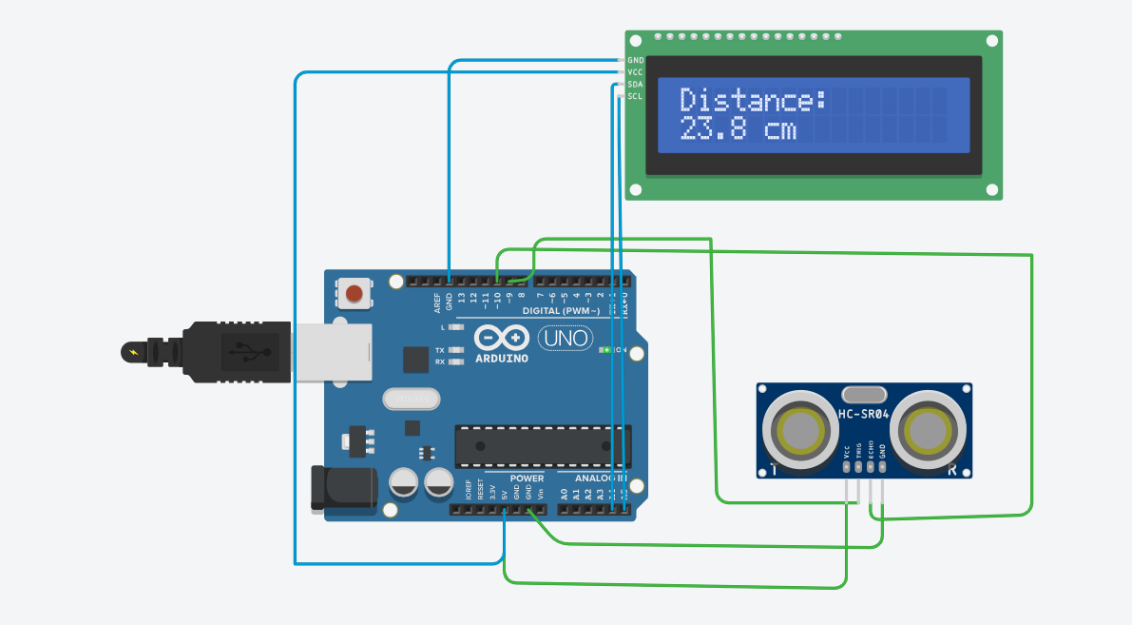

Figure 5: (Simuation based distance measurement using HC-SR04 ultrasonic sensor and output display in I2C LCD)

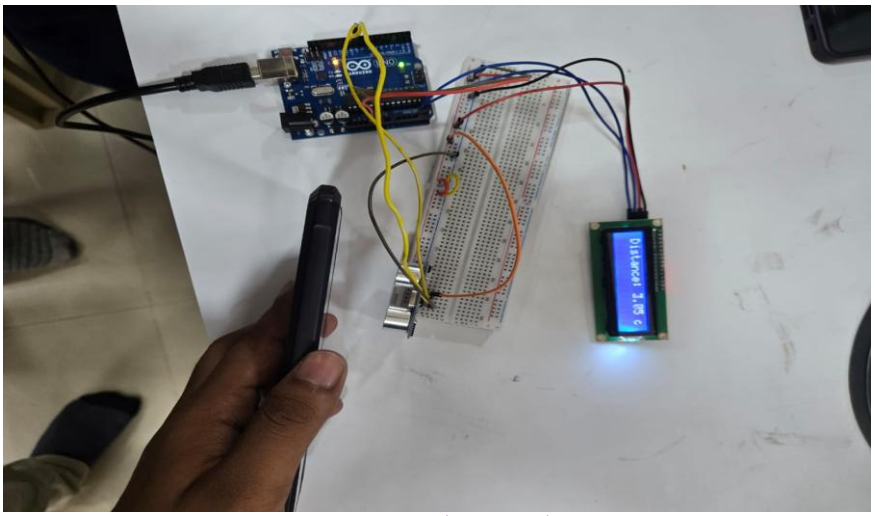

Figure 6: (Hardware Implementation based distance measurement using HC-SR04 ultrasonic sensor and output display in I2C LCD)

Objective 3

To interface IR sensor with Arduino Uno for obstacle detection using buzzer and LED.

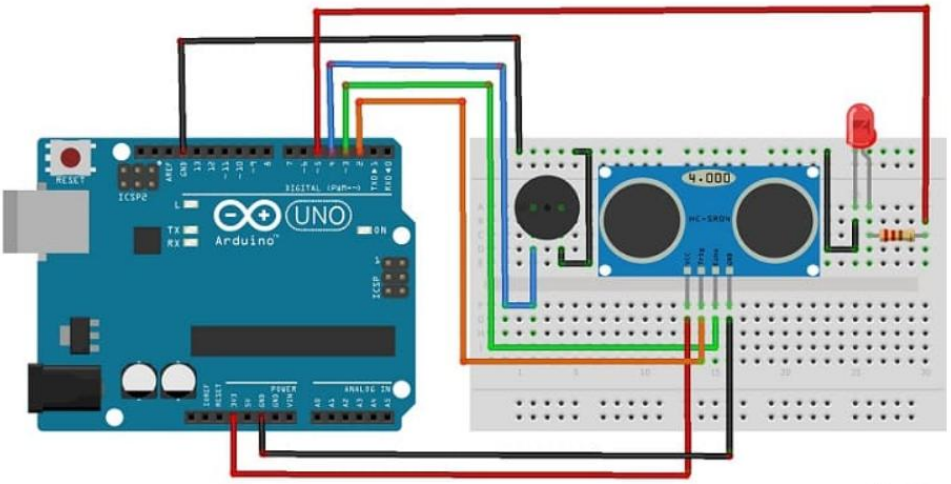

Figure 7: *Interface IR sensor with Arduino UNO for obstacle detection*

Code

Write an Arduino program to detect an obstacle in front, and turn ON the LED and buzzer.

```
#define TRIG_PIN    2
#define ECHO_PIN    3
#define LED_PIN     5
#define BUZZER_PIN  4

long duration;
int distance;

void setup() {
  pinMode(TRIG_PIN, OUTPUT);
  pinMode(ECHO_PIN, INPUT);
  pinMode(LED_PIN, OUTPUT);
  pinMode(BUZZER_PIN, OUTPUT);

  Serial.begin(9600);
}

void loop() {
  // Clear trigger
  digitalWrite(TRIG_PIN, LOW);
  delayMicroseconds(2);

  // Send 10 µs pulse
  digitalWrite(TRIG_PIN, HIGH);
```

```
  delayMicroseconds(10);
  digitalWrite(TRIG_PIN, LOW);

  // Read echo
  duration = pulseIn(ECHO_PIN, HIGH);

  // Convert to cm
  distance = duration * 0.034 / 2;

  Serial.print("Duration: ");
  Serial.print(duration);
  Serial.print("\tDistance: ");
  Serial.print(distance);
  Serial.println(" cm");

  // Buzzer and led activation when distance < 30
  if (distance > 0 && distance <= 30) {
    digitalWrite(LED_PIN, HIGH);
    digitalWrite(BUZZER_PIN, HIGH);
  } else {
    digitalWrite(LED_PIN, LOW);
    digitalWrite(BUZZER_PIN, LOW);
  }

  delay(500);
}
```

Observation

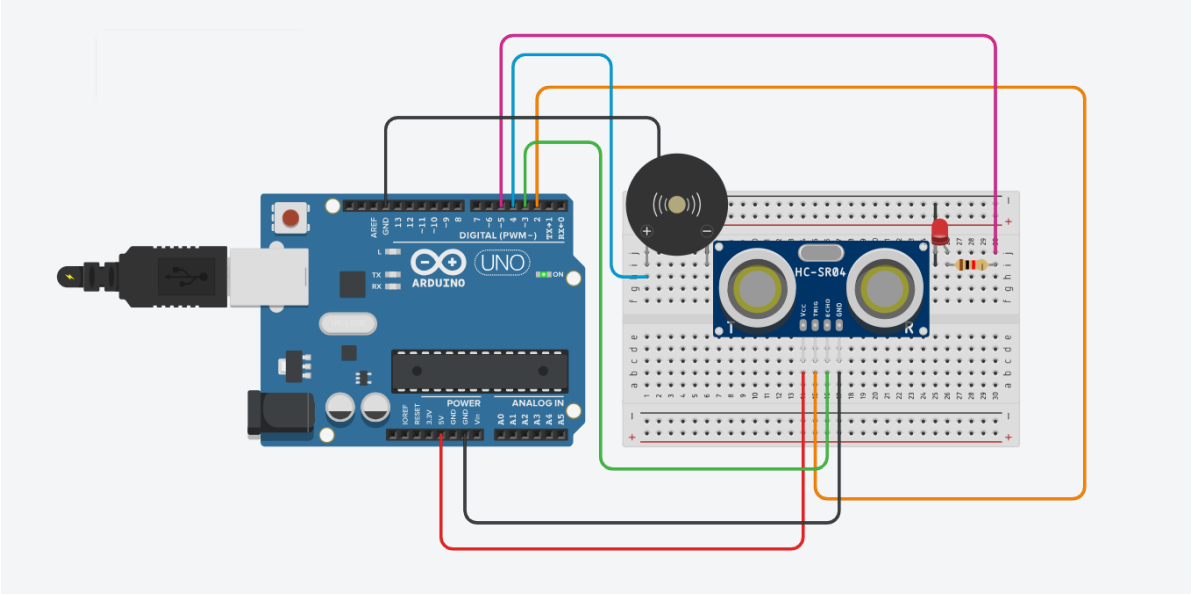

Figure 8: (*Simulation based interfacing IR sensor and buzzer with Arduino UNO for obstacle detection*)

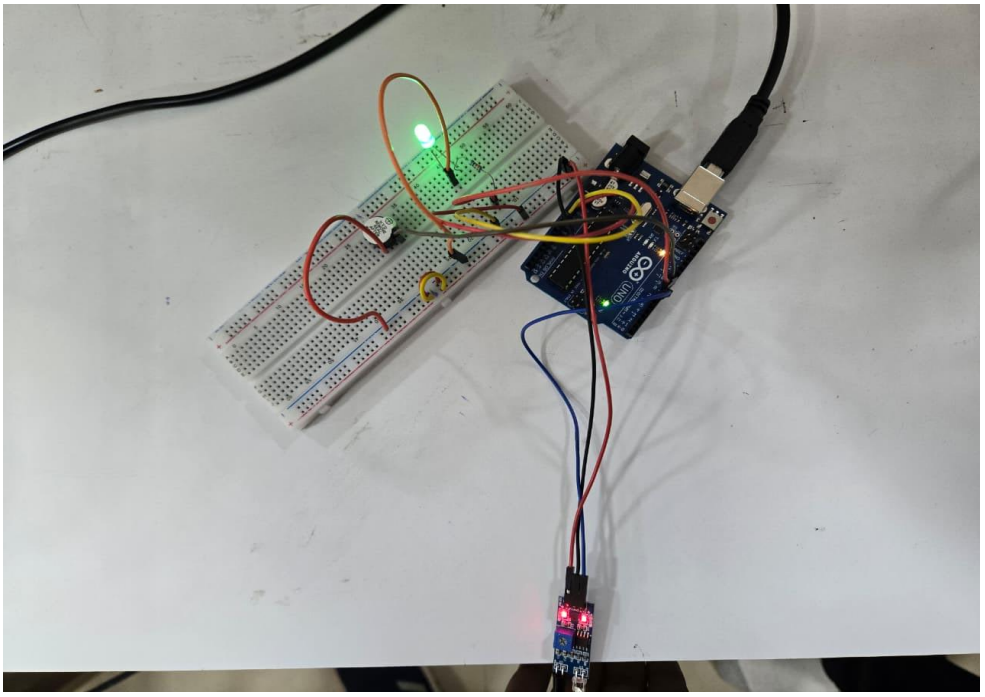

Figure 9: (*Hardware Implementation of interfacing IR sensor and buzzer with Arduino UNO for obstacle detection*)

Objective 4

To validate distance measurement of HC-SR04 ultrasonic sensor using LEDs as indicators.

Circuit / Schematic Diagram

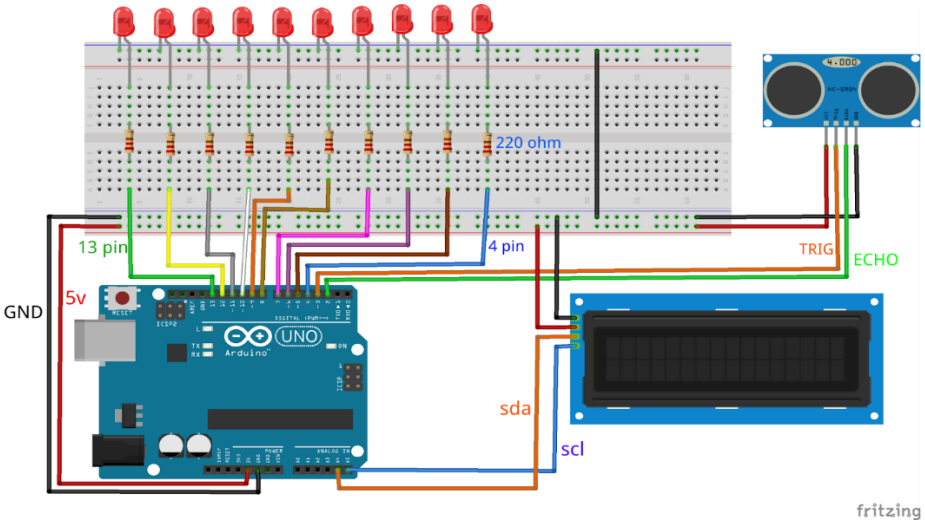

Figure 10: *HC-SR04 + Arduino Uno +LCD+LED*

Code

Write an Arduino program to integrate an ultrasonic sensor, an I2C LCD display, and LED indicators for real-time distance measurement and visualization.

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

#define TRIG_PIN 3
#define ECHO_PIN 2

// LEDs from pins 4–13
int leds[] = {4, 5, 6, 7, 8, 9, 10, 11, 12, 13};
const int ledCount = 10;

// Initialize I2C LCD (usually address 0x27 or 0x3F)
LiquidCrystal_I2C lcd(0x27, 16, 2);

void setup() {
  Serial.begin(9600);

  pinMode(TRIG_PIN, OUTPUT);
  pinMode(ECHO_PIN, INPUT);

  // setup all LEDs
  for (int i = 0; i < ledCount; i++) {
    pinMode(leds[i], OUTPUT);
  }

  // initialize LCD
  lcd.init();
  lcd.backlight();
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Distance Sensor");
  delay(1000);
}

void loop() {
  long duration;
  float distance;

  // Trigger pulse
  digitalWrite(TRIG_PIN, LOW);
  delayMicroseconds(2);
  digitalWrite(TRIG_PIN, HIGH);
  delayMicroseconds(10);
  digitalWrite(TRIG_PIN, LOW);
```

```
  // Read echo pulse duration
  duration = pulseIn(ECHO_PIN, HIGH, 30000);

  // Convert to cm
  distance = duration * 0.034 / 2;

  // Safety check: ignore invalid readings
  if (distance == 0 || distance > 400) {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Out of range   ");
    Serial.println("Out of range");
  } else {
    // Print distance
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Distance:");
    lcd.setCursor(10, 0);
    lcd.print(distance, 1);
    lcd.print("cm");

    Serial.print("Distance: ");
    Serial.print(distance);
    Serial.println(" cm");
  }

  // LED visualization (equal gaps from 4 cm to 320 cm)
  int numLEDs = map(distance, 4, 320, 0, ledCount);
  numLEDs = constrain(numLEDs, 0, ledCount);

  for (int i = 0; i < ledCount; i++) {
    if (i < numLEDs) {
      digitalWrite(leds[i], HIGH);
    } else {
      digitalWrite(leds[i], LOW);
    }
  }

  delay(300);
}
```

Observation

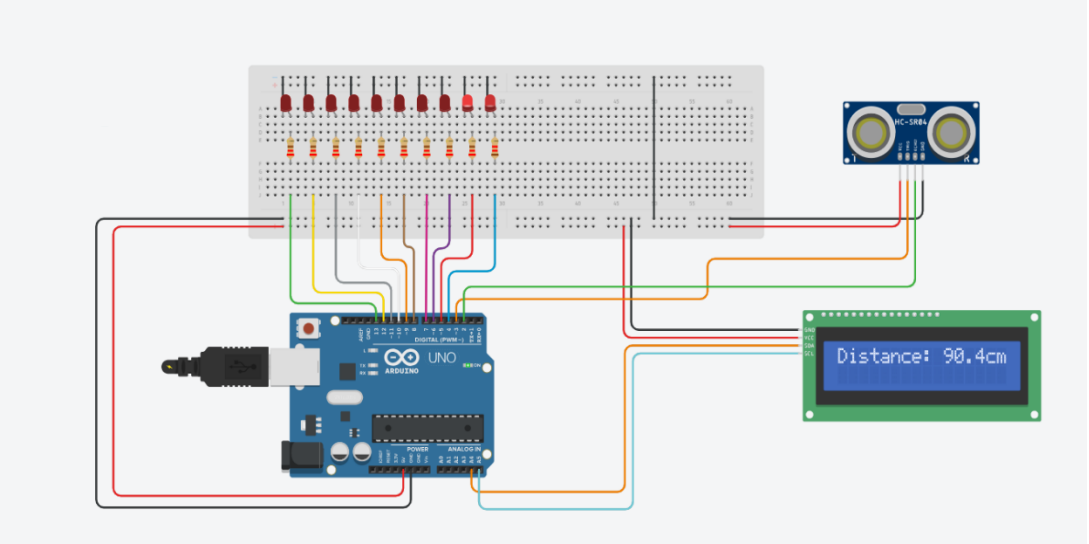

Figure 11: (*Software Implementation of interfacing ultrasonic sensor, an I2C LCD display, and LED indicators*)

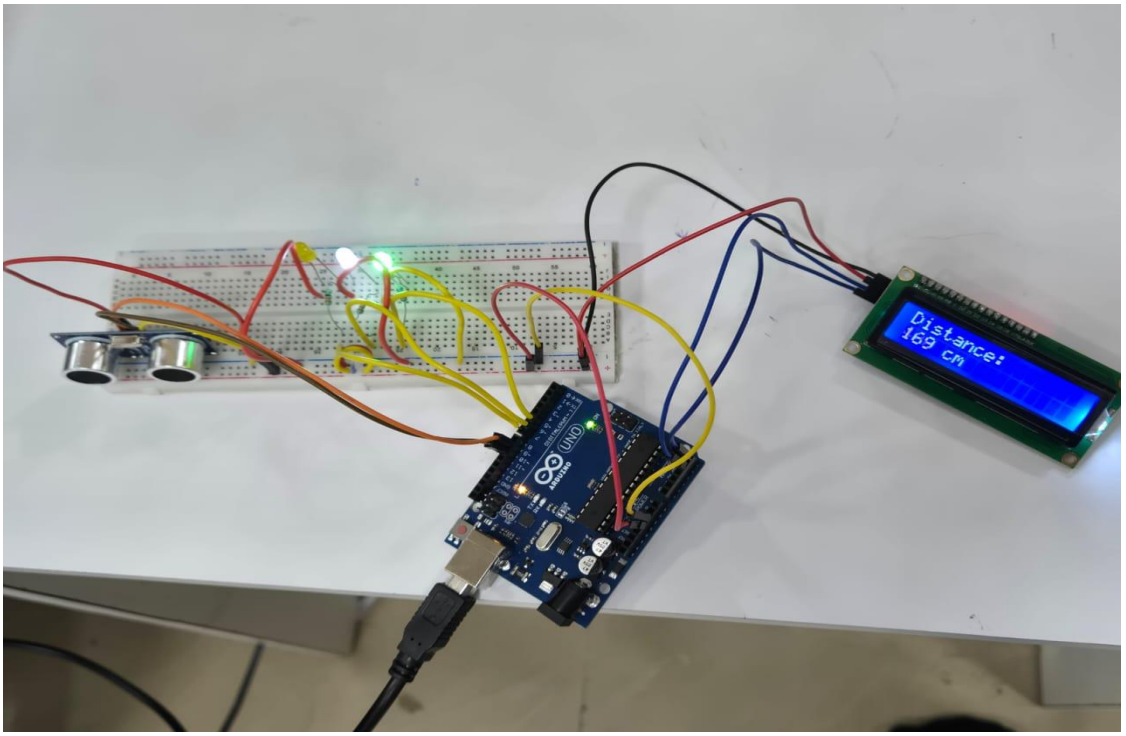

Figure 12: (*Hardware Implementation of interfacing ultrasonic sensor, an I2C LCD display, and LED indicators*)

Conclusion:

Precautions:

Post Experiment Questionnaire:

A. Experiment-Specific (LED Blinking & LED Patterns)

1. What happens if the Trigger pin of the HC-SR04 ultrasonic sensor is not given a proper 10 µs pulse?
2. If the Echo pulse duration is measured as 2 ms, calculate the distance of the obstacle. (Speed of sound = 343 m/s)
3. Why do ultrasonic sensors measure distance more accurately than IR sensors in outdoor conditions?
4. What would be the effect of bright sunlight on the IR sensor's performance?
5. How can you modify the Arduino code to turn ON an LED when an obstacle is detected within 15 cm using the HC-SR04 sensor?
6. If the ultrasonic sensor reads 200 cm, what should be the approximate Echo pulse duration?
7. Why is it necessary to divide the total sound travel time by 2 in ultrasonic distance measurement?
8. What logic output does the IR obstacle sensor provide when an object is detected?
9. Mention one limitation of using only IR sensors for obstacle detection in mobile robots.
10. Suggest a practical application where both ultrasonic and IR sensors are used together for better performance.?

(Signature of the Faculty)	**(Signature of the Student)**
	Name:
Date:	**Registration No.:**
	Branch:
	Section