VISION –The IoT SONAR

Contents

1. Abstract

The whole system is designed with an **objective to develop distance measurement system** using ultrasonic waves and interfaced with Arduino(UNO here). The human audible range lies between 20Hz to 20KH and this frequency range can be utilized through **HC-SR04**. The advantages of this sensor when interfaced with Arduino which is a control unit of the system, a proper distance measurement can be made with some calculation and sophisticated techniques. This distance measurement system can be widely used as range meters and as proximity detectors in industries. The hardware part of ultrasonic sensor is interfaced with Arduino. This method of measurement is efficient way to measure small distances precisely. The distance of an obstacle from the sensor is measured through ultrasonic sensor. After knowing the speed of sound the distance can be calculated.

2. Introduction

For the measurement of various units such as distance, angle we have used sources such as ultrasonic waves using ultrasonic sensors. This technique of distance measurement using ultrasonic in air includes **continuous pulse echo method**, a burst of pulse is sent for transmission medium and is reflected by an object kept at specific distance. The **time taken for the sound wave to propagate from transmitter to receiver is proportional to the distance** of the object. In this distance measurement system ultrasonic sensor HC-SR04 interfaced with arduino Uno. The control unit is a **Arduino Uno** which is a microcontroller board based on the **ATmega328** .

The sensor is mounted on top of a servo motor which gives the angle by which console has rotated and with the help of ultrasonic sensor distance is estimated.

3. Methodology and Technology

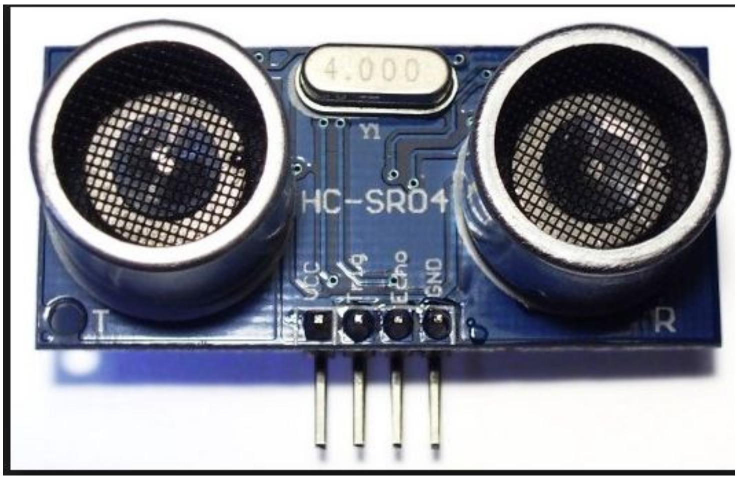
(a). Control Unit

Arduino Uno used as the computing part of system here is a **microcontroller board based on the ATmega328**. It has 14 digital input/output, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. "Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software

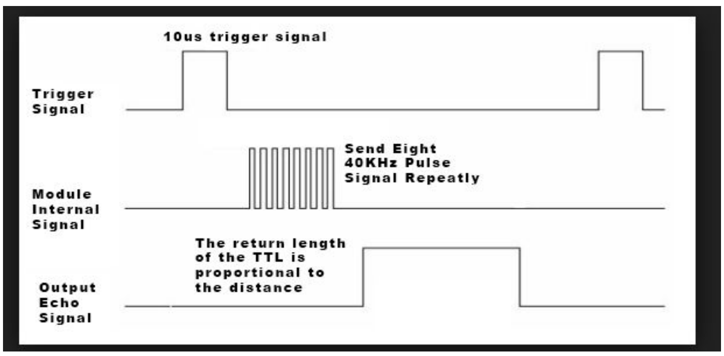
(IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards.

(b).Sensing Unit

The se**nsing unit here is HC-SR04** ultrasonic sensor. This sensor has 4 pins: Vcc (Voltage in), Trig (Trigger), Echo, and GND (Ground). The **Vcc pin requires 5 VDC** and the GND pin needs to be properly grounded. The Trig pin receives a pulse to start ranging and sends out a burst of ultrasound. The Echo pin receives the signal and calculates the time between sending a signal and receiving it.

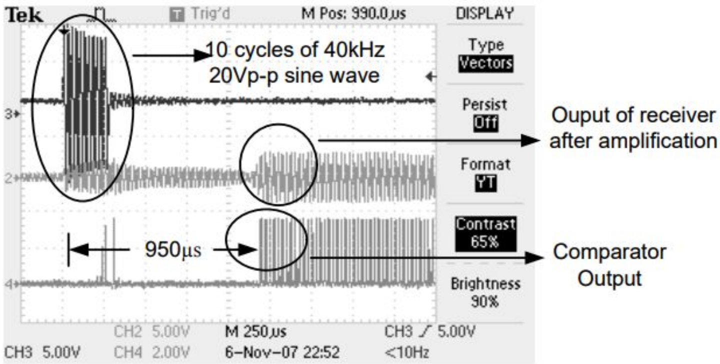


4. Working Principle of Transmitter and Receiver



In order to generate the ultrasound the **Trig is set on a High State for 10 µs**. That will send out a **8 cycle sonic burst** which will travel at the speed sound and it will be received in the Echo pin. The Echo pin will output the time in microseconds the sound wave travelled.

For example, if the object is 10 cm away from the sensor, and the speed of the sound is 340 m/s or 0.034 cm/µs the sound wave will need to travel about 294 u seconds. But what you will get from the Echo pin will be double that number because the sound wave needs to travel forward and bounce backward. So in order to get the distance in cm we need to multiply the received travel time value from the echo pin by 0.034 and divide it by 2.



Time of flight = 950µs

Distance measured = $\frac{330}{950\mu s}$ = 0.347 metres

Fig.2 Transmitted and Received Pulses

5. Calculation of Distance

The formulas in Equations 1 and 2 show how the distance to an object is calculated.

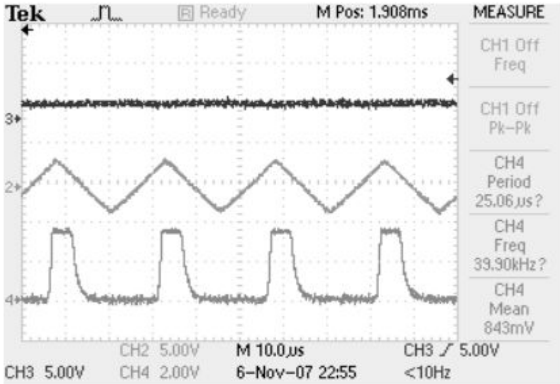
$$Distance\ (cm) = \frac{Time\ (uS)}{58}$$

$$Distance\ (Inch) = \frac{Time\ (uS)}{148}$$

Equation 1: Distance Calculation

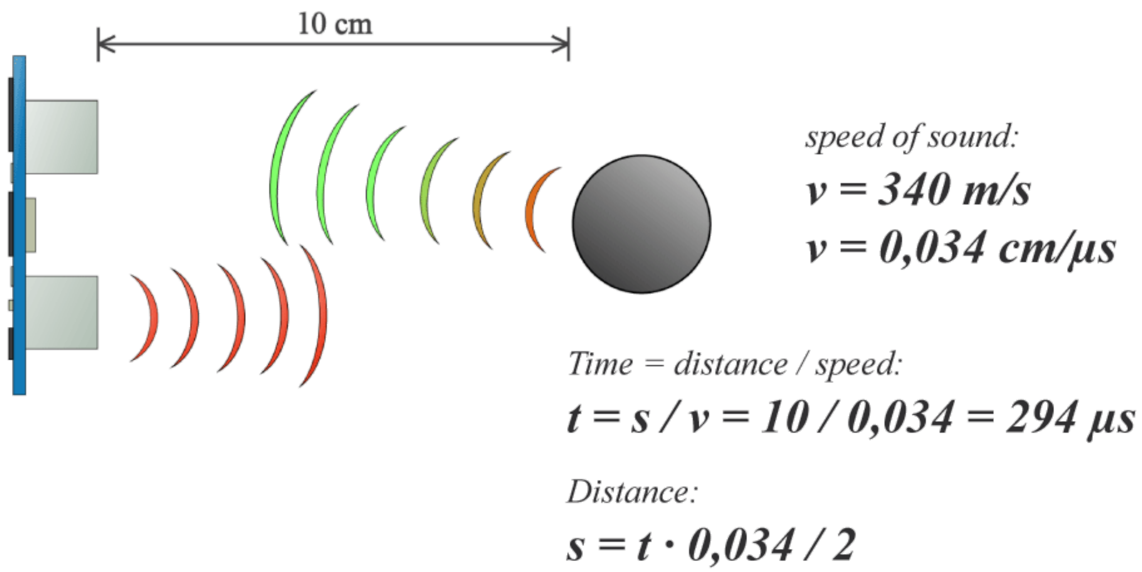
$$Range = \frac{(High\ Signal\ Time)(Speed\ of\ Sound)}{2}$$

Equation 2: Range of Sensor



Channel 3 : Output receiver amplifier
Channel 4 : Input pulses to the microcontroller.

It emits an ultrasound at 40 000 Hz which travels through the air and if there is an object or obstacle on its path It will bounce back to the module. Considering the travel time and the speed of the sound you can calculate the distance.



6. Measurement of Angle

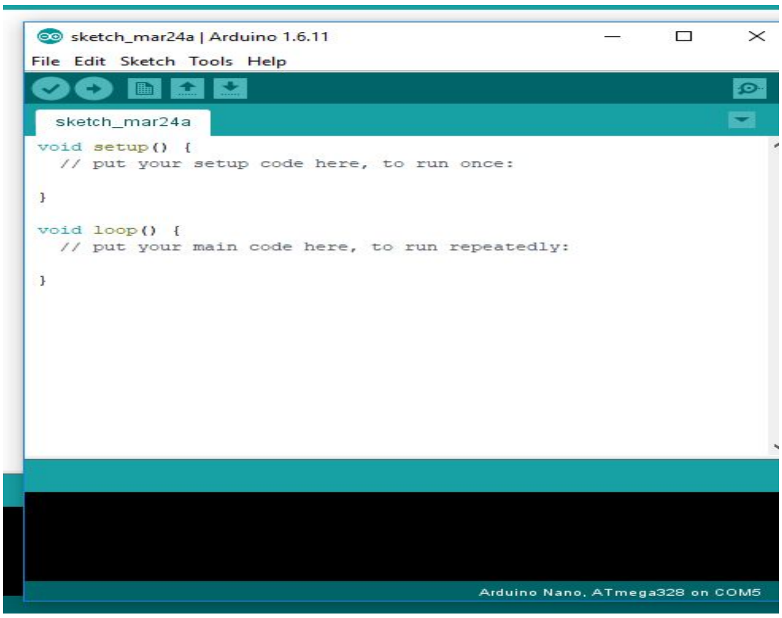
A **servo motor is a rotary actuator** that allows for precise control of angular or linear position, velocity and acceleration.It consists of a suitable motor coupled to a sensor for position feedback.

Here, we have programed the servo motor to rotate from 0° to 180° in steps incrementing by 1°. While rotating, ultrasonic sensor mounted on the motor is continuously checking for an obstacle in a defined range. If the sensor encounters an obstacle in that range, an interrupt is generated and the **servo motor returns the angle at which the obstacle was detected**.

7. Softwares used

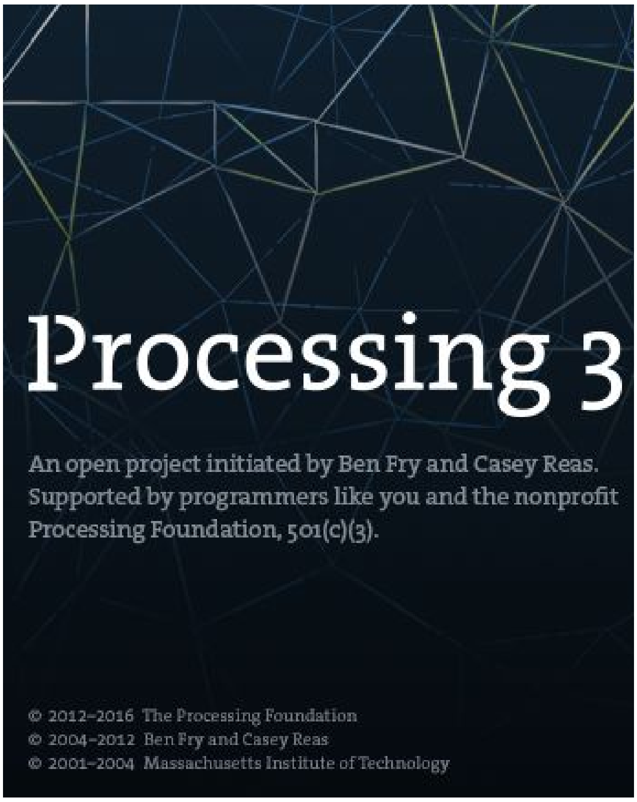
(a). Arduino 1.6.5

This software is capable of creating the sketches (code) for the Arduino board. **The 1.6.11 software has built in error checking and compiling**, but debugging will need to be done through a separate program The 1.6.5 software has built in libraries as well as the capability to download and implement libraries from the internet. The latter feature will be utilized for the initialization of the ultrasonic sensor. A blank sketch screen is shown below



(b). Processing

Processing is a flexible software sketchbook and a language for learning how to code within the context of the visual arts. Since 2001, Processing has promoted software literacy within the visual arts and visual literacy within technology



8. Arrangement of Devices

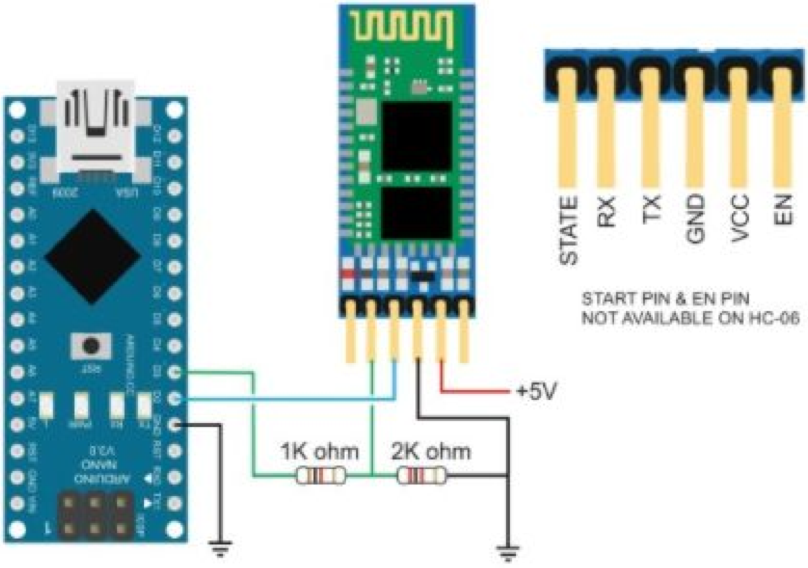
The Arduino board is the focal point of the design. The board supplies the power and ground strip to the sensor. A servo motor is attached to it for estimating the angle. **HC-SR04 is mounted vertically on top of servo motor.** For the final design, it is imperative to have the sensor's axis in vertical plane and at the centre to achieve high accuracy and precision in distance measurement, but for testing, the sensor can be in any configuration as long as the sensor stays steady.

Pins 8 and 9 will be utilized on the Arduino board for the **Echo and Trig pins** respectively. Pin 8 will be connected to the Trig pin and Pin 9 will be connected to the Echo pin. The servo motor's signal pin is connected to pin 10.

9. The IoT of system

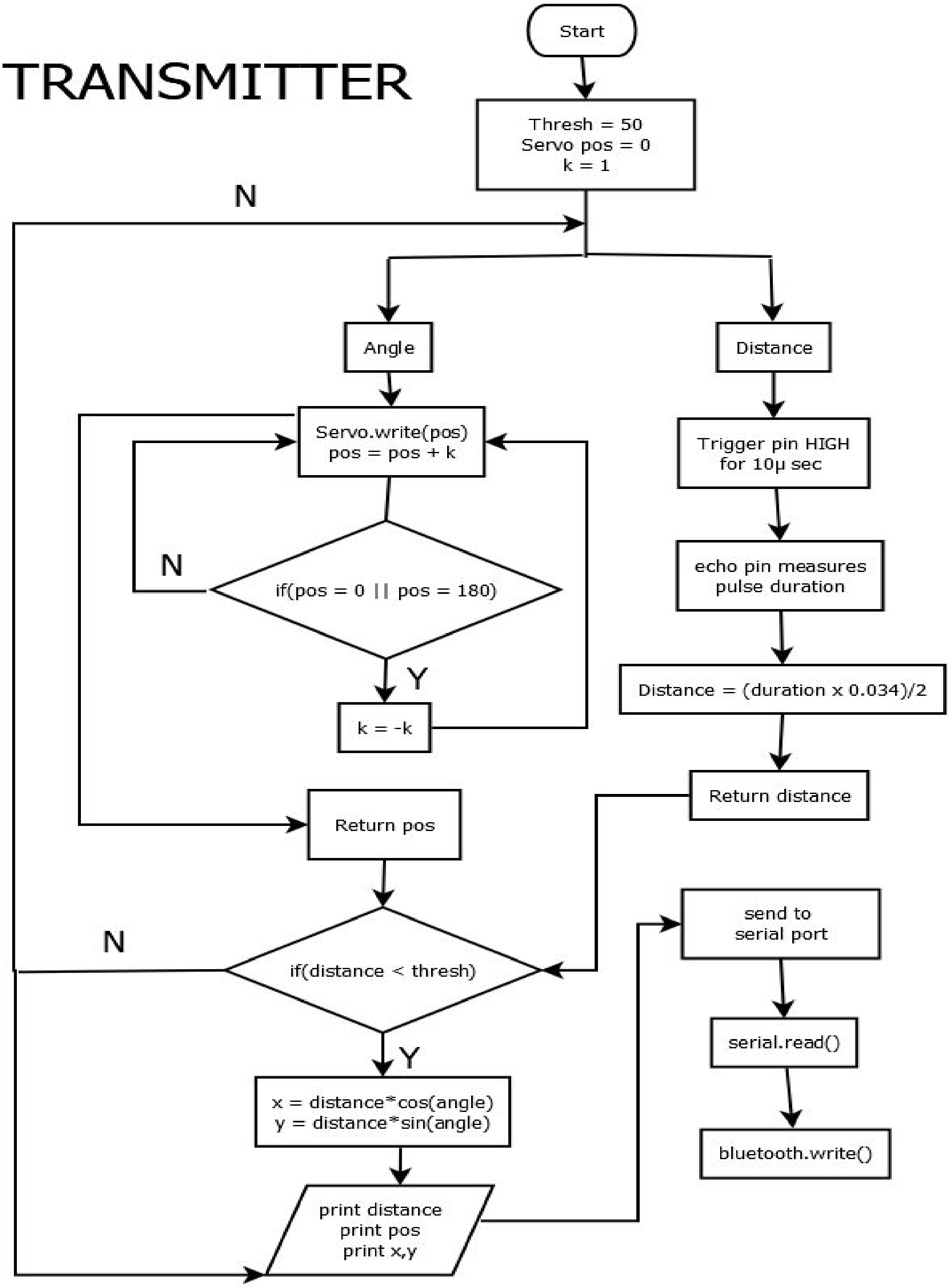
The physical communication channel of system is achieved **wirelessly through the Bluetooth module HC-05**. The master which here is arduino UNO is connected to a computer's Bluetooth and accessed via **Processing** which is a flexible software sketchbook. The slave is connected via HC-05 module which is connected to arduino nano and serves as a obstacle/object here. On account of receiving ultrasonic wave back on master side by means of ultrasonic sensor the code performs a series of calculation and sends the distance and coordinates to the slave over **96000 buad rate** and is displayed on a **16x1 LCD** attached to the object.

10. Connections

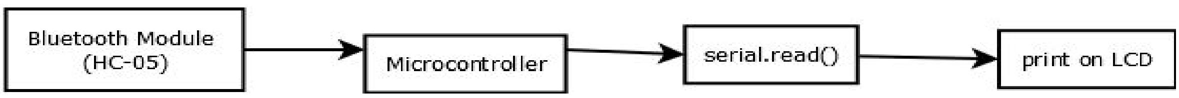


11. Flow chart of Vision

TRANSMITTER



RECEIVER

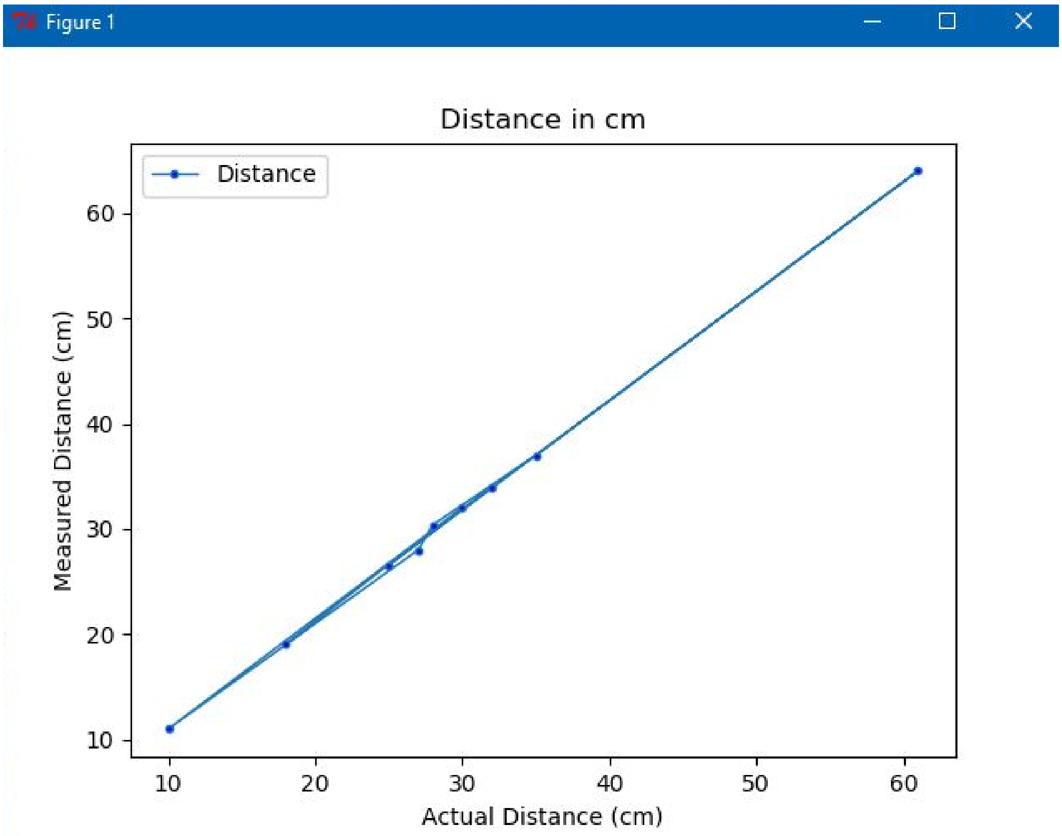


12. Performance of Vision

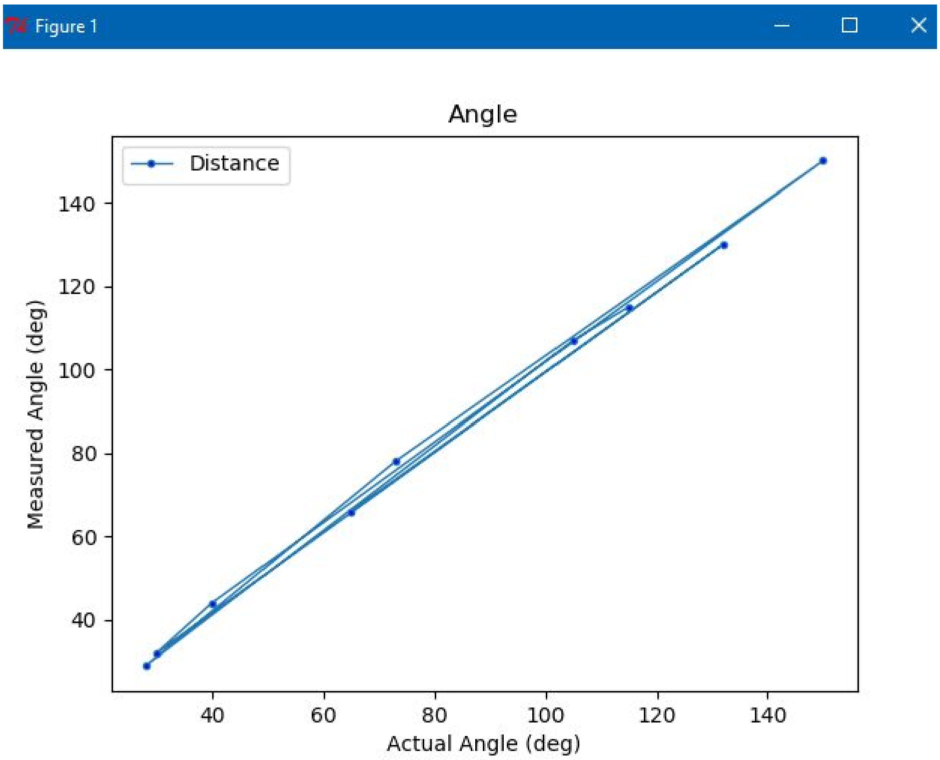
A test object of uniform thickness was taken and Graphs were plotted between :

i.)**Actual Distance and Measured Distance**

ii.)**Actual angle and Measured Angle**



(i)



(ii)

13. Parameters affecting the Ideal Plot

1.Temperature

- The temperature of the air between the sensor and the target can affect measurement accuracy since the s**peed of sound varies with temperature, i.e. 1% for every 5.7 °C.** As the temperature increases the target will measure closer, and vice versa.
- The ultrasonic sensor relies heavily on the speed of sound in the air:
  $$distance = \frac{speed\ of\ sound * elapsed\ time}{2}$$
- The speed of sound in the air can be represented as:
  $$c = 331.44\sqrt{1 + \frac{T}{273}}$$
  $$c = 331.45 + 0.6T$$, where T is the temperature in Celsius
  .Therefore, the speed of sound is 331.45 m/s at 0°C.
- To improve the performance of the sensor we have deployed temperature compensation circuitry.

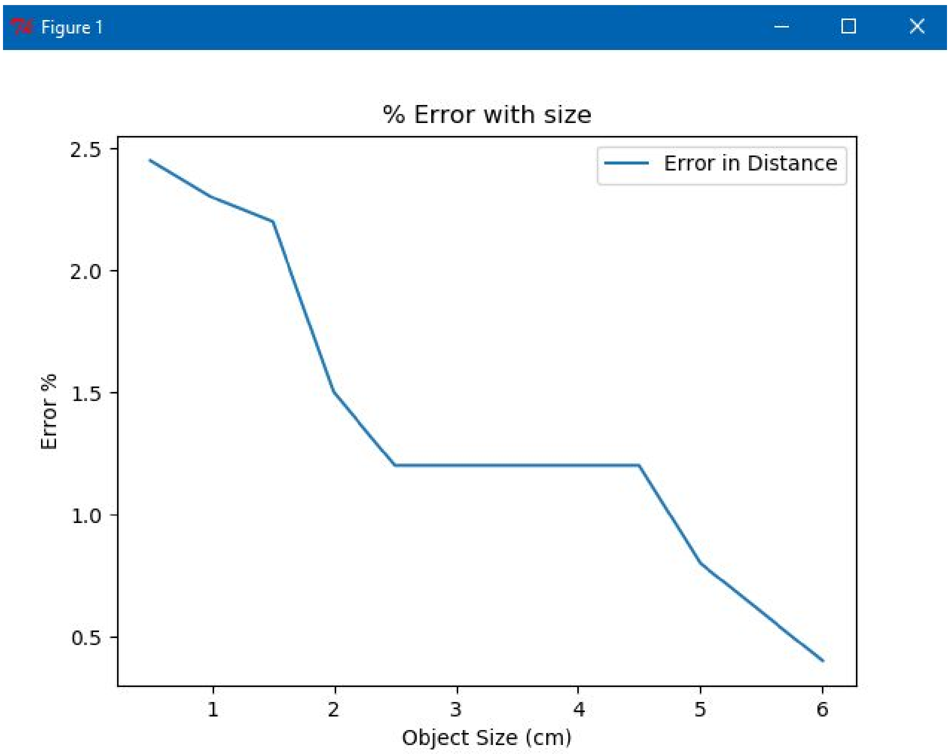
2.Humidity

Humidity change is generally not a significant factor **(0.036% / 10% RH change).**

3.Pressure/Vacuum

Normal atmospheric pressure changes or small pressure changes in vessels will not affect ultrasonic sensor operation. **Ultrasonic sensors are not designed for high pressure applications**. Sound does not travel in a vacuum.

14. Obstacle Resolution



Various sized objects were taken to determine the obstacle resolution.

- A pin sized object could not be detected with the present configuration.
- The minimum size of the obstacle which could be detected **was a pen with thickness of 0.5cm.**

- The maximum size that can be detected is **1.035m** as the maximum range of sensor is 4m and the cone angle is od 15 degrees.
- It was even observed that the **% error for the actual distance and measured distance reduced as the object size increased**. This was due to the fact that the sound waves were reflected off by surrounding objects.
- The maximum size of the obstacle which could be detected was :

15. Touch Detection Using Vision

The vision is capable of detecting where touch is being performed and return distance,angle and coordinates for the same. Suppose the touch is performed at an angle of theta**(θ)from the reference zero line in anti-clockwise direction**. The distance can be calculated from the formula

$$Distance\ (cm) = \frac{Time\ (uS)}{58}$$

For the touch being performed the coordinates can calculated by the relation

$$x(cm) = distance \times cos(\theta)$$

$$y(cm) = distance \times sin(\theta)$$

16. Hardware Novelty

The system consists of an operational amplifier IC741 for compensation of off set in the ultrasonic. The compensation helps in eliminating the random errors using a capacitor(10μFarad). When the **switch S1 is open the offset appears at the capacitor** and when **S2 is closed the output obtained is difference of input and offset.**

LM35 is also been employed to give compensation against the temperature changes as the speed of ultrasonic waves depends on temperature.

17. <u>Future Work</u>

• The range can be considerably increased by **using high power drive circuit**.

. • The resolution of the measurement can be improved by i**ncorporating phase shift method along with time of flight method.**

• The **40 kHz signal can be generated using microcontroller** itself which will reduce hardware.