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RASPBERRY PI PROJECT – ULTRASONIC DISTANCE SENSOR IN CIVIL ENGINEERING

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Abstract – *Civil engineers and architects need to have different approaches for measuring distances between the walls of the room and height of the building that do not require the human interaction. Instead of solid tools like long tapes, they can use sensors to determine distance. One of the solution is the ultrasonic distance sensors which uses ultrasonic sound (high frequency radio waves) to measure distance. This paper presents a system that measures the distance travelled by ultrasound waves through the air. The proposed system provides a tool for distance measurements in construction field for civil engineers to do the survey.*

Key Words: Robotics, Raspberry pi, Ultrasonic distance sensors, Civil engineers.

INTRODUCTION

Distance measurement of a target object from another object or thing is required in a many of devices. These devices may be of different size. These distance measuring devices uses various kinds of sensors and systems. In this paper, we describe such a distance measurement system which uses ultrasonic distance sensor and a Raspberry pi 4B microcontroller-based system. This Raspberry pi microcontroller easily available at low cost.

Table -1: Bill of Materials

Components Name	Quantity	Description
Raspberry Pi 4 with 32GB micro SD card	1	1GB or 2GB RAM
Ultrasonic distance sensors	1	HC-SR04 is an ultrasonic sensor
5V out Power bank	1	Two USB Out: 5V, 2.1Amp 1Amp
Breadboard	1	Small size
Resistors	2	1k/2k
Jumper wires	4	Male to female jumper wires

ULTRASONIC DISTANCE SENSOR

HC-SR04 is an ultrasonic distance sensor that is used to calculate the distance to the target object. It measures the distance between itself and the object. It uses a non-contact

technology to measure the distance. In non-contact there is no physical contact between sensor and object. It uses ultrasonic sound waves to measure the distance between itself and an object. It is used to measure distances in the range of 2cm to 400cm with an accuracy of 3mm.

Ultrasonic distance sensor contains 4 pins. Following table shows the description of all the 4 pins in the ultrasonic distance sensor:

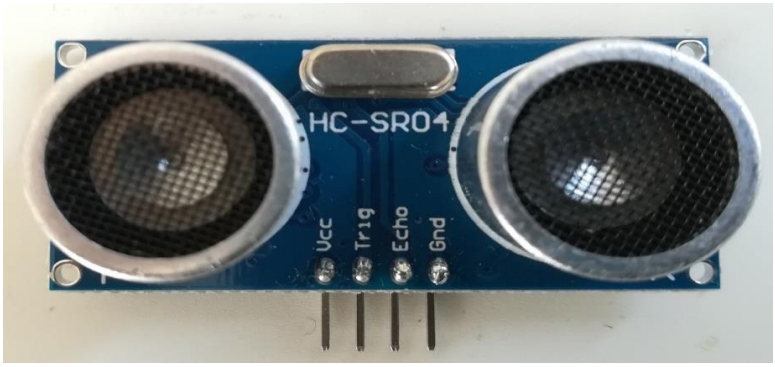

Fig -1: ULTRA SONIC DISTANCE SENSOR

Table -2: Distance sensor PINs

No	Name	Description
1	Vcc	The power supply pin of the sensor. It is connected to5V DC
2	TRIG	It is used to send out a signal
3	ECHO	It is used to receive a signal
4	GND	This pin is connected to ground

2.1 WORKING OF ULTRASONIC DISTANCE SENSOR

Ultrasonic distance sensor HC-SR04 has a transmitter and a receiver. Transmitter sends out an ultrasonic signal and receiver receives an ultrasonic signal. The property of the ultrasonic distance sound is whenever there is an object or obstacle standing in front of the sensor and the signal is sent out of the transmitter, it will go and strike the object that is there in its path and they are reflected back as echo signals to the receiver of the sensor.[2]

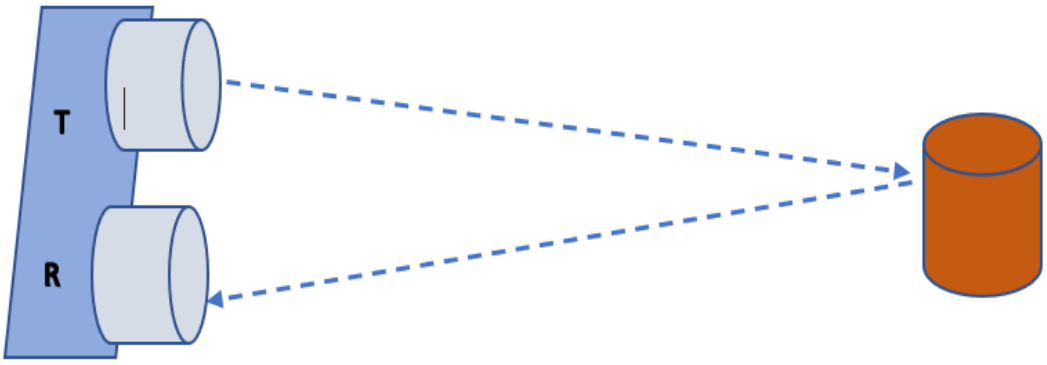

Fig -2: TRANSMITTER AND RECEIVER IN AN ULTRA SONIC DISTANCE SENSOR

The transmitter in the Ultrasonic Sensor generates a 40 KHz Ultrasound. The TRIG Pin of the Ultrasonic Sensor must be HIGH to send out a signal for a minimum duration of 10µS, because 10 µS is the length of the ultrasonic sound wave. Once the signal goes out of the transmitter, it propagates through air and if there is any obstruction in its path, the signal hits the obstruction and bounces back. This bounced signal is then received by the Ultrasonic Receiver. Based on time taken by the signal to transmit, hit the obstacle and receive back at the receiver, you can calculate the distance of the object as the speed of sound is already known.

2.2 How to Calculate Distance?

We will now see how to measure the distance of an object using HC-SR04 Ultrasonic Sensor. For example if the transmitter sends out a signal at time T1 and the signal goes out of the transmitter, strikes the object and is received back at time T2.

Time taken for the signal to transmit and receive back [1]

$$(T) = T2 - T1$$

Time taken in one direction=T/2

If we assume that speed of ultrasonic sound waves in air as S/sec

Now we know time taken by the signal to go and strike the object and speed of sound, then we can calculate the distance.

$$\text{Distance} = T/2 \times S$$

HARDWARE ASSEMBLY

As we know working of the HC-SR04 Ultrasonic Sensor, we will combine it with Raspberry Pi. In the Raspberry pi the GPIO pin corresponding to echo pin must be configured as Input pin and the GPIO pin corresponding to trig pin must be configured as output pin.[3]

- Vcc of the sensor will go into +5V of raspberry pi. Either to Pin # 2 or Pin # 4
- GND of the sensor will go into GND of raspberry pi
- Trig Pin of the sensor to Pin #40 of raspberry pi
- Echo Pin of the sensor into Pin # 12 of raspberry pi

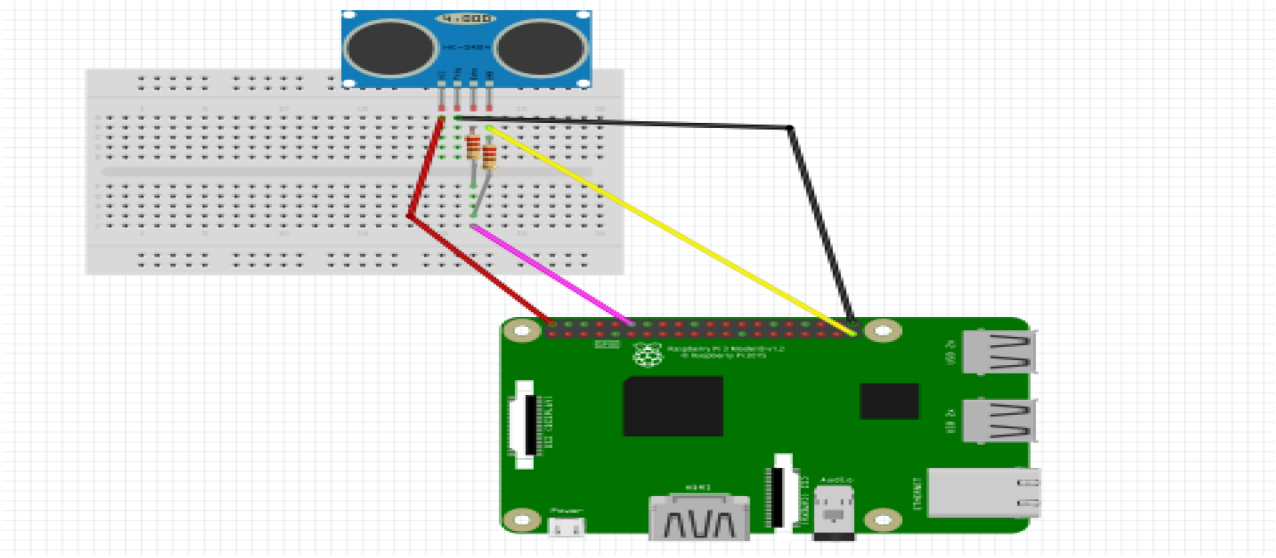

Fig -3: SENSOR CIRCUIT

SOFTWARE

In this project we have a single software module to calculate distance. Section of code to calculate distance is given below.

Code is written in python and it follow equation explained in section 2.2

```
while True:
   time.sleep(2)
   GPIO.output(TRIG,1)                    #Send
TRIG signal
   time.sleep(0.00001)
   GPIO.output(TRIG,0)
   while GPIO.input(ECHO) == 0:           # Capture
start time(T1)
      pulse_start = time.time()
```

```
    while GPIO.input(ECHO) == 1:
      pulse_end = time.time()                    #Capture
end time(T2)
    pulse_duration = pulse_end - pulse_start     # T2- T1 gives
total time of travel
    distance = pulse_duration * 17150
    distance = round(distance,2)
    print("distance: " + str(distance) + "cm")    # Print distance
GPIO.cleanup()
```

Application in Civil Engineering

The sensor circuit prototype can be upgraded to make a small module to measure distances. Main applications will be in civil engineering for conducting survey or taking building measurements. Civil engineer will be able to take different wall measurement standing in one place and without any assistance. This will avoid lot of manual effort and time.

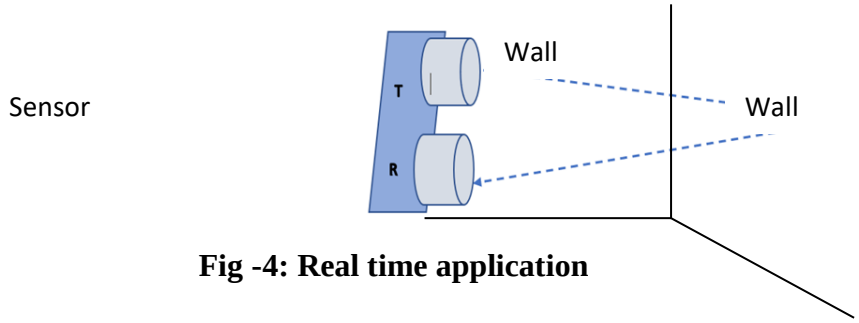

Fig -4: Real time application

TESTING AND RESULT

When we run the python code used in the ultrasonic distance sensor and raspberry pi interface, the sensor will display the distance to the target object.

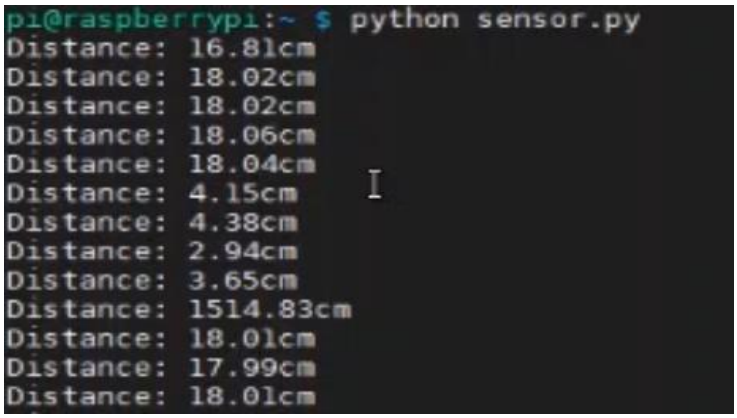

Fig -3: SENSOR CIRCUIT

CONCLUSION

In this paper, we are proposing a system that will calculate the distance between the walls and the height of the building. This will very useful for the civil engineers to measure the distances in different situations without the need of human intervention. This system will accurately measure the distances. We believe that this system will be of great help in the field of civil engineering.[4]

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