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Construction of an Automatic Waste Bin Operating Control System for Disposal of Refuse for Domestic and Public Use – Prototype

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ABSTRACT :

Smart dustbin is a carefully designed solution that solves the social issue of waste disposal; It work by sending out a sound wave at a frequency above the range of human hearing. The transducer of the sensor acts as a microphone to receive and send ultrasonic sound. The basic operation was achieved using some Arduino components like; Breadboard, Ultrasonic sensor, Jumper wires, Servo motor, Dustbin container, Arduino IDE (Integrated Development Environment) and Arduino Board. built with a microcontroller (ATMEGA328P). The microcontroller is embedded inside of Arduino board to control a singular function by interpreting data sent to it through Arduino IDE and releasing it as an output or Information. Ultrasonic sensor I was used to check the distance of an object close to the dustbin, Ultrasonic sensor II was used to measure the level of the waste bin when is filled up and the result was "if the distance is <= 40cm the dustbin will open and delay by one seconds and closed by itself and When the dustbin is filled up the dustbin will remain closed until the dustbin is emptied".

Keywords: Arduino, microcontroller, Servo motor, Ultrasonic Sensor, Plastic bucket

Introduction

Trash Cans are small plastic (or metal) containers that are used to store trash (or waste) on a temporary basis. They are often used in homes, offices, streets and parks etc. to collect waste. In some places, littering is a serious offence hence public waste containers are the only way to dispose small waste. It is a common practice to use separate bins for collecting wet or dry bins. The surrounding of a dustbin is also conducive for increasing the pollution level. Air pollution due to dustbin can produce bacteria and viruses which can produce life harmful diseases for human. Garbage in Nigeria is a very serious problem and also become a social, economic, cultural in commerce. Almost all cities in Nigeria experience problems in waste management. The highest focus is the accumulation of plastic waste. Every individual would want everything that looks clean and beautiful, one of which is environmental cleanliness. There are still many individuals who tend to be less aware of the cleanliness of their environment. This is reflected in a large amount of garbage scattered on the street and city parks. The situation certainly creates unrest to the society. In this project, is shown the design of a simple system called Smart Dustbin using; Arduino, ultrasonic sensor I, ultrasonic sensor II, bread board, Jumper wires and servo motor, where the lid of the dustbin will automatically open itself upon detection of human hand or movement in front of the Ultrasonic sensor.

A Smart Dustbin by Monika (2016), Smart Dustbin-An Efficient Garbage Monitoring System in which the smart bin was built on a plat form which was based on Arduino Uno board which was interfaced with a GSM Modern and an Ultrasonic Sensor. The sensor was placed on the top of the bin. A threshold level was set at 10cm. as the garbage reaches the level of threshold; the sensor triggers the GSM modern which alerts the associated authority till the garbage in the bin is emptied. At the end a conclusion was made that various issues like affordability, maintenance and durability were addressed when these Smart bins were designed. It also contributed towards a hygienic and clean environment in the process of building a smart city. Anitha, Paul and Kumari (2016),designed Garbage Monitoring system, which monitors the garbage bins and informs about the level of garbage collected in the garbage bins via a web page. It shows the System Architecture, in which system uses ultrasonic sensors placed over the bins to detect the garbage level and compare it with the garbage bins depth. The proposed system uses Arduino family microcontroller (The LPC2131/32/34//38

microcontrollers are based on a 16/32- bit ARM7TDMI-S CPU with real-time emulation), LCD screen, Wi-Fi modem (The ESP8266 supports APSD for VoIP applications and Bluetooth co-existence interface) for sending data and a buzzer, GSM (used to send message to the garbage depot if the garbage can exceed the set threshold level) Ultrasonic Sensor (Sensor sends out a high-frequency sound pulse and then times how long it takes for the echo of the sound to reflect back. IOT Based Smart Garbage Monitoring System, in which dustbins are interfaced with microcontroller, based system having Ultrasonic sensors with wireless systems. These wireless systems central system showing current status of garbage, on mobile web application with connected via Wi-Fi. Anitha et.al (2016) proposed a home automation system using IOT uses raspberry for the implementation. Also proposed a model for cyber security systems using artificial system to have secured transactions. Navghane, et.al (2016); proposed A IOT Based Smart Garbage and Waste Collection Bin, briefly tells that this is regarding a trash bin which is connected with a microcontroller. This microcontroller has a system based on the IR wireless and also central system. IR wireless is use of wireless technology in devices or systems that convey data through infrared (IR) radiation. Infrared is electromagnetic energy at a wavelength or wavelengths somewhat longer than those of red light. Central system used as shown the status of trash by web browser. This project depends on the working of the Wi-Fi module; essential for its implementation. Wi-Fi module (wireless fidelity) also known as WLAN modules (wireless local area network) are electronics component used in many products to achieve a wireless connection to the internet. Combination of sensors of weight and IR sensor gives the amount of weight and the separate level. Monika et.al, (2016), proposed A Smart Dustbin based on IoT in which the smart bin was built on a platform which was based on Arduino Uno board which was interfaced with a GSM modem and an ultrasonic sensor. This sensor was placed on the top of the bin. A threshold level was set as 10cm. As the garbage reaches the level of threshold, the sensor triggers the GSM modem which alerts the associated authority till the garbage in the bin is emptied. At the end, a conclusion was made that various issues like affordability, maintenance and durability were addressed when these smart bins were designed. It also contributed towards a hygienic and clean environment in the process of building a smart city. Chaware, et.al (2017); proposed an integrated system of Wi-Fi modem, IoT, GSM, Ultrasonic Sensor is introduced for efficient and economic garbage collection. The developed system provides improved database for garbage collection time and waste amount at each location. It analyzed the solutions currently available for the implementation of IoT. By implementing this project, then will avoid over flowing of garbage from the container in residential area which is previously either loaded manually or with the help of loaders in traditional trucks. It can automatically monitor the garbage level & send the information to collection truck.

Lokhande, et.al, (2016); proposed a system that able to observe the different type garbage is thrown into dustbin by using sensors. In this system there are two technologies are used like Zigbee and Global system for Mobile communication (GSM).

In 2005, building upon the work of Hernando Barragán (creator of Wiring), Massimo Banzi and David Cuartielles created Arduino, an easy-to-use programmable device for interactive art design projects, at the Interaction Design Institute Ivrea in Ivrea, Italy. David Mellis developed the Arduino software, which was based on Wiring. Before long, Gianluca Martino and Tom Igoe joined the project, and the five are known as the original founders of Arduino.

Materials and Methodology

Arduino UNO Board, Arduino IDE, HC-SR04 Ultrasonic Sensor Module, Bread-Board, Servo Motor, Connecting Wires, 5V Power Supply, A small dustbin with hinged lid, Miscellaneous (glue, plastic tube, etc.), 12V battery, USB Connector

Arduino Uno Board

The Arduino Uno (one) is an open source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a USB cable. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. The word "uno" means "one" in Italian and was chosen to mark the initial release of Arduino Software.

Arduino IDE

The Arduino Integrated Development Environment (IDE) is a cross-platform application (for Windows, Linux) that is written in functions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of third-party cores, other vendor development boards.

Image Source: https://docs.arduino.cc/static/4106ba9a36bb5b73bc95520a96f785ea/a6d36/AEK-CH2-SC2.1-ARDUINO-IDE.png

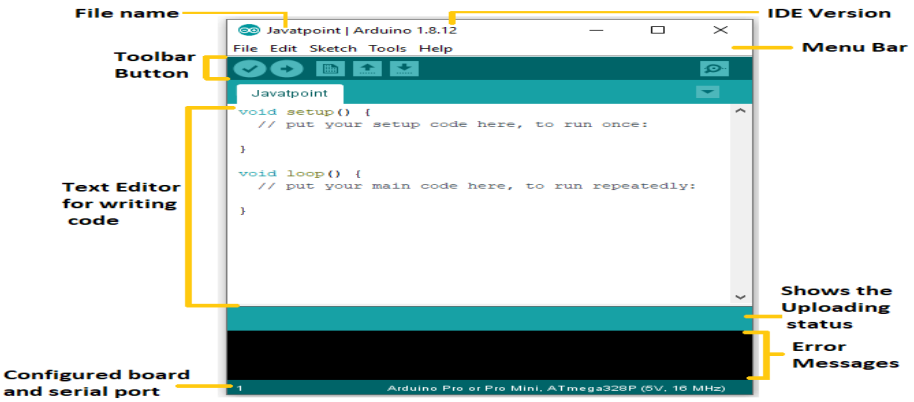

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Fig 1 Block diagram of Arduino IDE

Void set up():

A function present in every Arduino sketch Run once before the loop() function often used to set pin mode to input or output. Syntax

Void setup () {// code goes here}

Void loop() : A function present in every Arduino Sketch , this code happens over and over again the loop is where almost everything happens. The syntax;

Void () {

//code goes here

Arduino Software or IDE uses a simplified version of C++, making it easier to learn to program. Arduino IDE was writing with C or C++ that is why most of the write up use in Arduino IDE in programming the hardware is same write up used in C++ programming language.

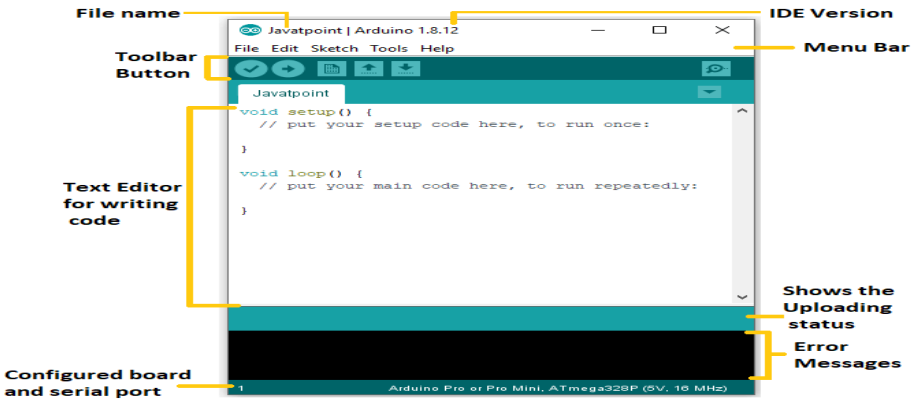

Fig 2 Block diagram of Ultrasonic sensor

Servo Motor

A servo motor is a DC motor integrated with a gear train, a shaft encoder, and some control logic so that it is easier to use. It has a limited rotation, typically 180°. A servo motor has a 3-pin interface with power (typically 5 V), ground, and a control input. The control input is typically a 50 Hz pulse-width modulated signal. The servo's shaft encoder is typically a rotary potentiometer that produces a voltage dependent on the shaft position. In a typical servo motor with 180 degrees of rotation, a pulse width of 1ms drives the shaft to 0°, 1.5 ms to 90°, and 2 ms to 180°.

HC - SR04 Ultrasonic Sensor

Ultrasonic sensors work by sending out a sound wave at a frequency above the range of Human hearing. This sensor is a very popular sensor used in many applications where measuring distance or sensing objects are required. The module has two eyes like projects in the front which forms the Ultrasonic transmitter and Receiver. The Ultrasonic transmitter transmits an ultrasonic wave, this wave travels in air and when it gets objected by any material it gets reflected back toward the sensor this reflected wave is observed by the Ultrasonic receiver module as shown in the picture below.

Image Source; https://i.pinimg.com/736x/a6/6a/40/a66a407cfc3e613b510035fbe795610a.jpg.

Pin configuration for ultrasonic sensor module (HC- SRO4) WHICH INCLUDES;

VCC(5 Volt SUPPLY)

TRIGGER PIN

ECHO PIN

GND (0VOLT)

Test distance = (high level time-velocity of sound (340m/s)/2) sound travels at approximately 340 meters per seconds. This corresponds to about 29.41µs (microseconds) per centimeter. To measure the distance the sound has travelled we use the formula:

$$S = \frac{Vt}{2} \qquad (1)$$

$$\text{Distance} = \frac{(\text{Speed of sound} * \text{Time})}{2}$$

The 2 is in the formula because the sound has to travel back and forth. First the sound travels away from the sensor, and then it bounces off of a surface and returns back. The easy way to read the distance as centimeters is used the formula: Centimeters = ((Microseconds / 2) / 29.

Bread-baoard

A breadboard, or protoboard, is a construction base for prototyping of electronics. Originally the word referred to a literal bread board, a polished piece of wood used when slicing bread. This makes it easy to use for creating temporary prototypes and experimenting with circuit design. For this reason, solderless breadboards are also popular with students and in technological education. Older breadboard types did not have this property.

Jumper Wires

Jumper wires are used for making connections between items on your breadboard and your Arduino's header pins. Use them to wire up all your circuits.

Power supply

The board can operate on an external supply from **7 to 20 volts**. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may become unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

USB Connector

USB-C (Universal Serial Bus) is an industry-standard for transmitting both data and power over a single cable. The benefits of USB include increased data transfer rates (DTRs) and faster charging capabilities.

Methodology

Smart Dustbin using Arduino is an Arduino based project. Here we are using Arduino for code execution, for sensing we used ultrasonic sensor which will open lid and wait for few moment and we also used ultrasonic sensor for measuring the level of garbage bin. It will bring drastic changes in terms of cleanliness with the help of sensor. Everything is getting with smart technology for the betterment of human being. So this help in maintaining the environment clean with the help of Ultrasonic sensor that senses human close to the dustbin. It is a sensor based dustbin so it would be easy to access/use for any age group. My Aim is also to make it cost effective so that many numbers of people can get the benefit from this. And it should be usable to anyone and helpful for them. The materials used are; Arduino UNO Board, Arduino IDE, HC-SR04 Ultrasonic Sensor Module., Bread-Board, Servo Motor., Connecting Wires., 5V Power Supply., A small dustbin with hinged lid., Miscellaneous (glue, plastic tube, etc.), 12V battery, USB Connector

Construction and testing materials used

The materials used in testing the smart dustbin are:

i. **Project Board:** This is a white electronic kit, which is used to test and construct electronic circuit without soldering the components. It provides room for circuit modification if need be.

ii. **Connecting Wires:** These are tiny pieces of copper wires about $0.2mm^2$ in diameter. They are used to assemble components together on the project board.

iii. **Battery:** The source dc supply is 9volts high watt battery or 12V.

iv. **Software:** which is the Arduino IDE

v. **Serial Monitor:** to check if the code is running properly

Working principle of ultrasonic sensor

Ultrasonic sensors work by sending out a sound wave at a frequency above the range of human hearing. The transducer of the sensor acts as a microphone to receive and send the ultrasonic sound. Our ultrasonic sensors, like many others, use a single transducer to send a pulse and to receive the echo. The Ultrasonic sensor Circuit consists of a set of Utrasonic receiver and transmitter which operate at the same frequency. When something moves in the area covered the circuit's fine balance is disturbed and the alarm is triggered. The ultrasonic circuit is very sensitive and can be adjusted to reset itself automatically or to stay triggered till it is reset manually after an alarm. The table and graph below shows the analysis of ultrasonic sensor readings comparison between the sensor value and actual distance value. The actual readings were measured by using measuring tape. The ranges of reading of the ultrasonic sensor are between 10cm until 40cm. The readings difference between the sensor reading and actual reading are almost same actual reading. The difference is only 1cm.

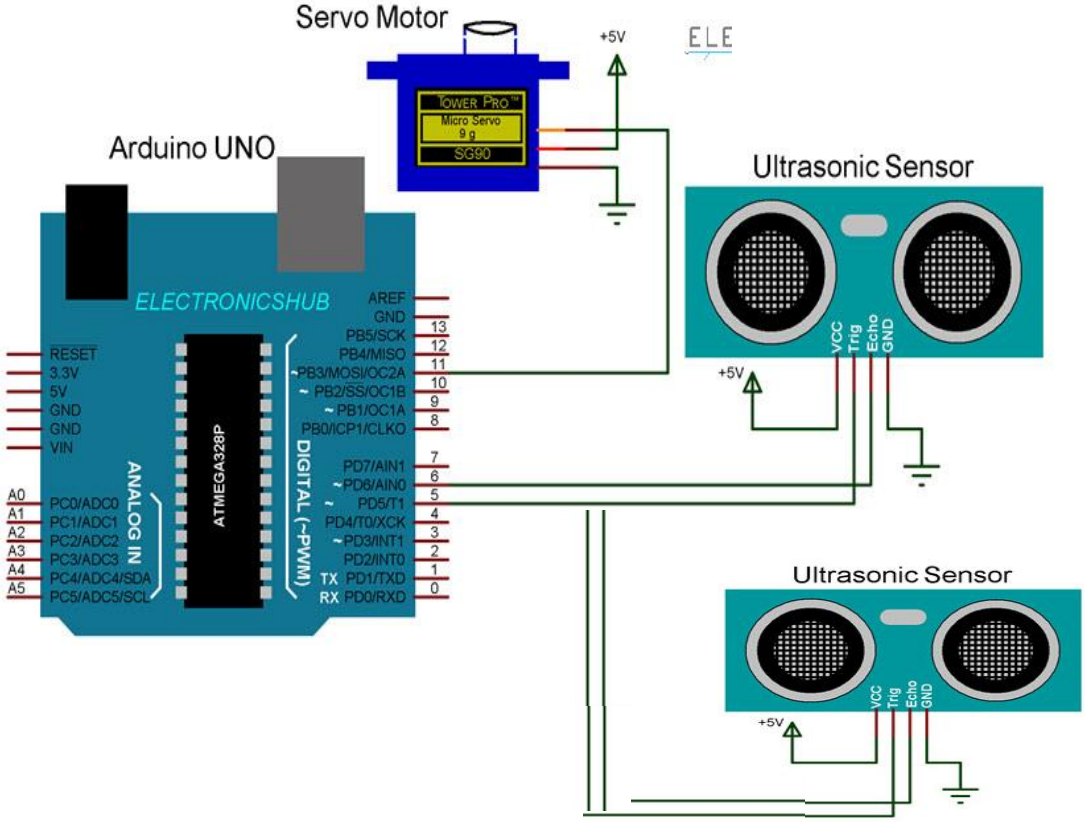

Image source;
https://www.google.com/url?sa=i&url=https%3A%2F%2Fprojectiot123.com%2F2023%
Fig: 3 Block diagram of Smart Dustbin.

STEPS ON HOW TO BUILD SMART DUSTBIN:

Step 1: Servo motor placed on the Plastic dustbin.

Fig.3.1 Diagram showing how Servo motor placed on the Dust Bin

Step 2: I Placed the 2 Ultra Sonic Sensors

Fig.3.2 Diagram showing how Servo motor was placed on the Trash Bin

Place the ultra sonic sensor in the dustbin as shown in the picture and move on to the next step.

Step 3: Programmed the Arduino

Connected the arduino and uploaded the given program on your arduino uno and place the arduino in the dustbin with the help of double tape or gum and move on to the next step.

Step 4: wiring the components

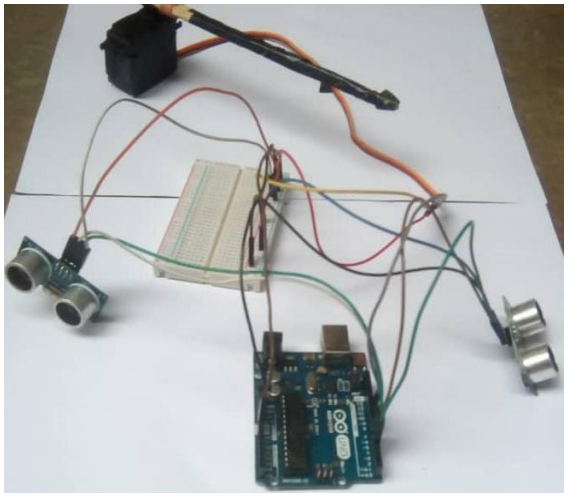

Fig.3.4 wiring of the components

Now, connect the circuit as shown in the picture above and then move on to the next step.

Smart Dustbin code

```
 Smart Dust Bin Code
  Smart Dustbin
  By ODOEMELAM

  25 November 2022
  Written by Odoemelam Paul Onyedikachi
*/

#include <Servo.h>

//Variables declaration
constintutrasonic_front_trig = 6;
constintutrasonic_front_echo = 7;
unsigned long utrasonic_front_total_time;
floatutrasonic_front_distance;

//Top ultrasonic sensor
constintutrasonic_top_trig = 3;
```

```
constintutrasonic_top_echo = 2;
unsigned long utrasonic_top_total_time;
floatutrasonic_top_distance;

constintservo_pin = 10;
intbin_time_open = 3000;   //Time the bin will be open
floatdustbin_proximity = 60;

Servo myservo;
voidopenBin(){
myservo.write(180);
Serial.println("Bin open");
delay(bin_time_open);
floatnew_distance = 0;
while(new_distance<= dustbin_proximity){
     //Measuring distance of the front ultrasonic sensor
digitalWrite(utrasonic_front_trig, LOW);
delayMicroseconds(2);
digitalWrite(utrasonic_front_trig, HIGH);
delayMicroseconds(10);
digitalWrite(utrasonic_front_trig, LOW);

utrasonic_front_total_time = pulseIn(utrasonic_front_echo, HIGH);
new_distance = (utrasonic_front_total_time * 0.034) / 2;
Serial.print("New distance in cm is = ");
Serial.println(new_distance);
Serial.println("Bin open");
delay(500);
   }
}
voidcloseBin(){
myservo.write(90);
}
void setup() {
Serial.begin(9600);

pinMode(utrasonic_front_trig, OUTPUT);
pinMode(utrasonic_front_echo, INPUT);

pinMode(utrasonic_top_trig, OUTPUT);
pinMode(utrasonic_top_echo, INPUT);

myservo.attach(servo_pin);

  //Reset dustbin to close mode
closeBin();  //Resets the bin to closed mode
delay(2000);
}
void loop() {
  //Measuring distance of the front ultrasonic sensor
digitalWrite(utrasonic_front_trig, LOW);
delayMicroseconds(2);
digitalWrite(utrasonic_front_trig, HIGH);
delayMicroseconds(10);
digitalWrite(utrasonic_front_trig, LOW);

utrasonic_front_total_time = pulseIn(utrasonic_front_echo, HIGH);
utrasonic_front_distance = (utrasonic_front_total_time * 0.034) / 2;
Serial.print("Distance in cm is = ");
Serial.println(utrasonic_front_distance);
delay(500);

if(utrasonic_front_distance<= dustbin_proximity){
   //checking if the bin is filled up

   //Measuring distance of the top ultrasonic sensor
digitalWrite(utrasonic_top_trig, LOW);
delayMicroseconds(2);
digitalWrite(utrasonic_top_trig, HIGH);
delayMicroseconds(10);
digitalWrite(utrasonic_top_trig, LOW);

utrasonic_top_total_time = pulseIn(utrasonic_top_echo, HIGH);
utrasonic_top_distance = (utrasonic_top_total_time * 0.034) / 2;
Serial.print("top Distance in cm is = ");
```

```
Serial.println(utrasonic_top_distance);
delay(1000);

   //check if the bin is filled up
if(utrasonic_top_distance> 5){
openBin();
Serial.print("bin is not filled");
}else{
Serial.print("bin is filled");
   }
   //Serial.println("Bin open ");

   //openBin();
  }
closeBin();
Serial.println("Bin closed");
```

Calculations:

The distance of Human close to the Ultrasonic Sensor can be calculated using this formula as follows:

Distance = speed of sound x time

Speed of sound is giving as = 353m/s

To convert the speed to microseconds;

353m/s x $\frac{1000}{10^{-6}}$ = 0.353cm/µs

S = $\frac{Vt}{2}$ (2)

Distance = $\frac{(\text{Speed of sound} * \text{Time})}{2}$ (3)

Distance = $\frac{0.0353\text{cm}/\mu\text{s} \times 3\text{s}}{2}$ (4)

Distance = 5.29 x $10^{-3}m$

Result and Discussion

Ultrasonic sensor transmits the ultrasonic waves and receives the waves when they come back by hitting any human. So, when the human detects in front of the dustbin it sends some signal to the Arduino which we are using as a controller in this work. Now, the Arduino gets the data and analyzes the data for further processing so that the dustbin can operate well. Arduino analyses the data. The Ultrasonic sensor sends the received signal to the Arduino which calculates the distance by the duration of sound waves.

Table 1 Analysis of ultrasonic

Sensor reading (cm)	Actual reading in (cm)
10	9
15	15
20	19
25	26
35	36
40	39

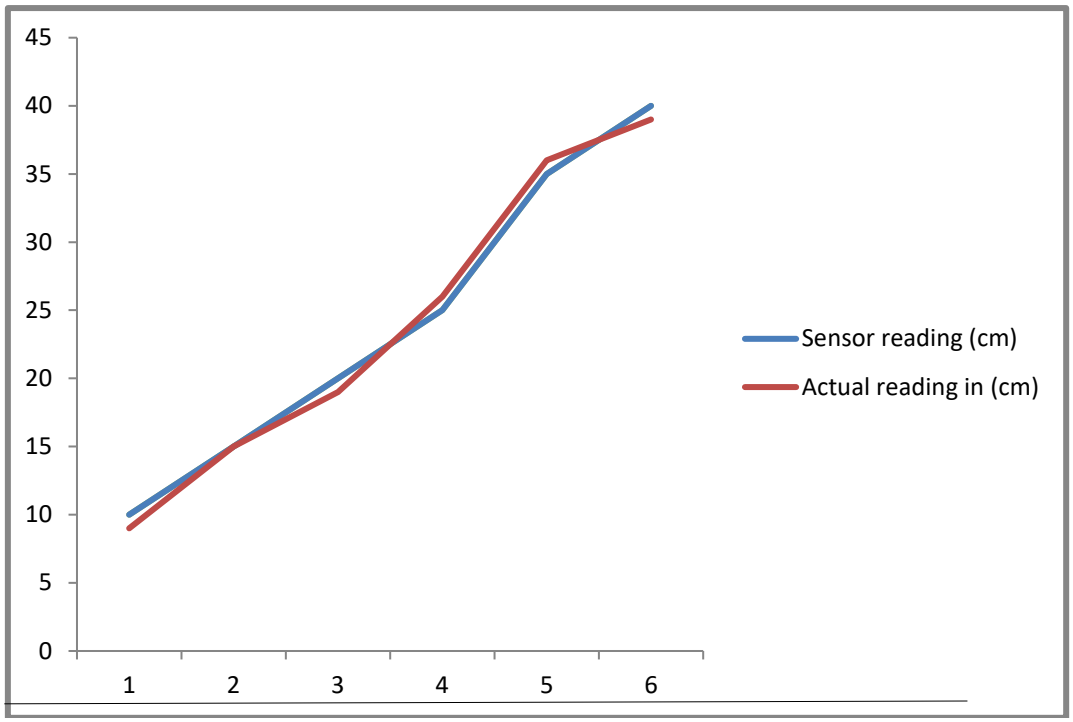

Fig: 4 graph below shows the analysis of ultrasonic sensor readings comparison between the sensor value and actual distance value

Conclusion

Conclusively this work aims at developing the affordable smart dustbin using Ultrasonic sensor with the aid of a Servo motor, we were able to build an automatic open and close smart dustbin. That detect any human in front of it, it opens and after receiving trash, it closes by itself and it also measures the level of garbage in the dustbin. This design and construction was archived after going through several literature reviews of which the principle of smart city was discussed and the beginning of smart dustbin also put into view. We can say that, it is a decent gadget to make your home clean and attractive. Also it will help to reduce the transmission of disease like, COVID-19 a virus that has killed so many people in the world today though smart dustbin was possible after testing the project and also the affordable components.

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