1. Introduction

Continued exposure to environments with poor air quality is a major public health concern in developed and developing countries. It is estimated that the pollutants responsible for poor air quality cause nearly 2.5 million premature deaths per year world-wide. Significantly, around 1.5 million of these deaths are due to polluted indoor air, and it is suggested that poor indoor air quality may pose a significant health risk to more than half of the world's population. Due to its link with industrialisation, societal health problems associated with poor air quality disproportionately affects developed and developing nations – it is estimated that air pollution is responsible for the premature deaths. Remedial action to improve air quality is often easy to implement once airborne pollutants have been detected.

Air pollution has become a common phenomenon everywhere. Specially in the urban areas, air pollution is a real-life problem. A lot of people get sick only due to air pollution. In the urban areas, the increased number of petrol and diesel vehicles and the presence of industrial areas at the outskirts of the major cities are the main causes of air pollution. The problem is seriously intensified in the metropolitan cities. Also, the climate change is now apparent. The governments all around the world are taking every measure in their capacity. Many European countries have aimed to replace petrol and diesel vehicles with the electric vehicles by 2030. Even India has aimed to do so by 2025. The use of coal for electricity generation is now going to be a thing of past. The nations are now focusing to generate energy from nuclear reactors and the renewable resources like solar energy, wind energy and hydroelectric power.

It is now important to monitor air pollution in real time in most of the urban areas. This project is aimed at developing an IOT device which can monitor air pollution in real time and log data to a remote server. Remote monitoring was facilitated using classical motes in the past, which has some pitfalls like limited memory, processing speed and complex programming strategies. By using Internet of Things and recording sensor data to a remote server, the limitations of memory in the monitoring devices and manual collection of data from the installed devices can be overcome. The IOT also helps monitoring the data in real time.

2. Requirement Analysis

2.1Hardware Requirement Specification:

The Arduino Uno :

Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins of which 6 can be used as PWM outputs, 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.. You can tinker with your Uno without worrying too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again.The USB port in the Arduino board is used to connect the board to the computer using the USB cable. The cable acts as a serial port and as the power supply to interface the board. Such dual functioning makes it unique to recommend and easy to use for beginners.

USB Cable:

Cable For Arduino UNO/MEGA is the most common A to B Male/Male type peripheral

USB cable for Arduino. It is compatible with most Arduino boards such as Arduino Mega, Uno, Arduino Duemilanove. Often used for printers and other peripherals. While still a little bulky in shape for small embedded systems, this is a standard cable

found everywhere. Use this cable with Arduino UNO and others, but not for Arduino Leonardo based boards.

Specifications and Features:

- Length 50 cm
- Hot Pluggable.
- Fully compatible with the PC.
- Molded strain relief and PVC over molding to ensure a lifetime of error-free data transmissions.
- Foil and braid shield complies with fully rated cable specifications reducing EMI/FRI interference.

Package Includes: 1 x Cable For Arduino UNO/MEGA (USB A to B).

Jumper Wire:

Generally, jumpers are tiny metal connectors used to close or open a circuit part. They have two or more connection points, which regulate an electrical circuit board.

Their function is to configure the settings for computer peripherals, like the motherboard. Suppose your motherboard supported intrusion detection. A jumper can be set to enable or disable it. Jumper wires are electrical wires with connector pins at each end. They are used to connect two points in a circuit without soldering. You can use jumper wires to modify a circuit or diagnose problems in a circuit. Further, they are best used to bypass a part of the circuit that does not contain a resistor and is suspected to be bad.

Jumper Wire Colours : Although jumper wires come in a variety of colours, they do not actually mean anything. The wire colour is just an aid to help you keep track of what is connected to which. It will not affect the operation of the circuit. This means that a red jumper wire is technically the same as the black one.

Types of Jumper Wires: Jumper wires come in three versions:

a. Male-to-male jumper
b. Male-to-female jumper
c. Female-to-female jumper: And two types of head shapes: square head and round head. The difference between each is in the endpoint of the wire. Male ends have a pin protruding and can plug into things, while female ends do not but are also used for plugging. Moreover, a male connector is referred to as a plug and has a solid pin for centre conduction. Meanwhile, a female connector is referred to as a jack and has a centre conductor with a hole in it to accept the male pin. Male-to-male jumper wires are the most common and what you will likely use most often.

BUZZER:

An audio signalling device like a beeper or buzzer may be electromechanical or mechanical type. The main function of this is to convert the signal from audio to sound. Generally, it is powered through DC voltage and used in timers, alarm devices, printers, alarms, computers, etc. Based on the various designs, it can generate different sounds like alarm, music, bell & siren.

It includes two pins namely positive and negative. The positive terminal of this is represented with the '+' symbol or a longer terminal. This terminal is powered through 6Volts whereas the negative terminal is represented with the '-'symbol or short terminal and it is connected to the GND terminal.

LED:

Light-emitting diode (LED) is a widely used standard source of light in electrical equipment. It has a wide range of applications ranging from your mobile phone to large advertising billboards. They mostly find applications in devices that show the time and display different types of data. A light-emitting diode (LED) is a semiconductor device that emits light when an electric current flows through it. When current passes through an LED, the electrons recombine with holes emitting light in the process. LEDs allow the current to flow in the forward direction and blocks the current in the reverse direction. Light-emitting diodes are heavily doped p-n junctions. Based on the semiconductor material used and the amount of doping, an LED will emit coloured light at a particular spectral wavelength when forward biased.

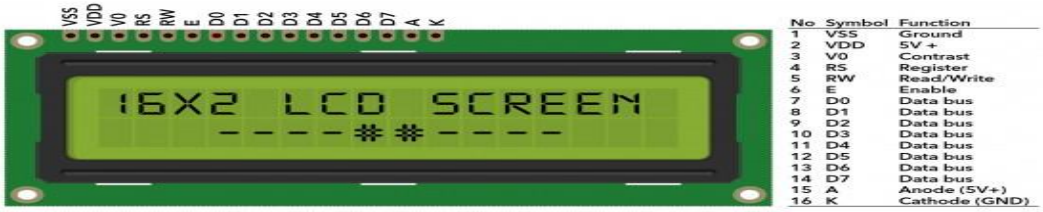
MQ3 SENSOR:

The MQ3 alcohol sensor is one of the series of MQ gas sensors, which can detect and monitor the alcohol gas present in the atmosphere. It is capable of detecting 25-500ppm alcohol gas concentration in the air. This article gives a brief description of the pin configuration, specifications, and Arduino interfacing of the MQ3 alcohol sensor. The alternatives of MQ3 alcohol sensors are MQ138 (benzene, hydrogen, alcohol, propane, toluene, formaldehyde gas), MQ303A (ethanol, smoke, and alcohol), MQ2(methane, smoke, LPG, butane), MQ214 (methane), MQ5 (natural gas and LPG), and MQ306A (LPG and butane). The MQ3 alcohol gas sensor is a module used for detecting alcohol, CH4, benzene, gasoline, hexane, CO, and LPG. It has a sensitive material SnO2 for alcohol gas detection, with lower electrical conductivity in the fresh air. It is a semiconductor alcohol gas sensor that detects or monitors the presence or absence of alcohol. It is also known as **chemiresistors** because sensing of the sensitive material depends on the resistance change when the sensor is exposed to alcohol gas.

LCD :

LCD (Liquid Crystal Display) is a type of flat panel display which uses liquid crystals in its primary form of operation. LEDs have a large and varying set of use cases for consumers and businesses, as they can be commonly found in smartphones, televisions, computer monitors and instrument panels.

LCDs were a big leap in terms of the technology they replaced, which include light-emitting diode (LED) and gas-plasma displays. LCDs allowed displays to be much thinner than cathode ray tube (CRT) technology. LCDs consume much less power than LED and gas-display displays because they work on the principle of blocking light rather than emitting it. Where an LED emits light, the liquid crystals in an LCD produces an image using a backlight.



No	Symbol	Function
1	VSS	Ground
2	VDD	5V +
3	V0	Contrast
4	RS	Register
5	RW	Read/Write
6	E	Enable
7	D0	Data bus
8	D1	Data bus
9	D2	Data bus
10	D3	Data bus
11	D4	Data bus
12	D5	Data bus
13	D6	Data bus
14	D7	Data bus
15	A	Anode (5V+)
16	K	Cathode (GND)

2. Literature Survey

The difficulty of the conventional monitoring instruments is their large size, heavy weight and extraordinary costlier. These lead to inadequate deployment of the monitoring stations. In order to be effective, the locations of the monitoring stations need careful placement because the air pollution situation in urban areas is highly related to human activities (e.g. construction activities) and location-dependent (e.g., the traffic choke-points have much worse air quality than average). IOT Based Air Pollution Monitoring System monitors the Air Quality over a webserver using internet and will activate an alarm when the air quality goes down beyond a certain level, means when there is amount of harmful gases present in the air like CO2, smoke, alcohol, benzene, NH3, NOx and LPG. The system will show the air quality in PPM on the LCD and as well as on webpage so that it can be monitored very easily. Temperature and Humidity is detected and supervised in the system. An Air Pollution Monitoring System for monitoring the combination of major air pollutant gases has been designed, developed, and observed with the wireless standard. This system measures combination of gases such as CO, NO2 and SO2, and using semiconductor sensors. The hardware unit integrates a single-chip microcontroller, air pollution sensors array,

a GSM-Module and a GPS-Module. The Central-Server is a high-end personal computer application server with internet connectivity. The hardware unit gathers air pollutants levels (CO,

NO2, and SO2), and packs them in a frame with the GPS physical location, time, and date. The frame is finally uploaded to the GSM-Modem and transmitted to the Central-Server via wireless network. The Environmental air pollution has significant influence on the combination of constituents in the atmosphere leading to effects like global warming and acid rains. To avoid such harmful imbalances in the nature, an air pollution measuring system is utmost important. The traditional air quality monitoring system, controlled by the Pollution Control Department, is extremely costlier. Wireless Sensor Networks are a new and very challenging research field for embedded system design automation, as their design must enforce stringent constraints in terms of power and cost. This attempts to develop an effective solution for pollution measuring using wireless sensor networks (WSN). It focuses on development of a prototype for a Wireless Sensor Network (WSN) that supervises various environmental guidelines of interest in urban areas based on ZigBee protocol. This is observed through a small device that can be placed anywhere in a city. First, it is studied the operation of ZigBee protocol. Second, it was chosen and tested a ZigBee module and sensors from the market. Then, it was developed a module that supervises: humidity, temperature, light, carbon monoxide, carbon dioxide and oxygen. These data are measured and sent regularly to a base station connected to a computer. These data are stored and processed for presentation on the Internet in this Environment Observation and Forecasting System (EOFS) is an application for supervising and providing a forecasting about environmental circumstances. The air pollution Monitoring system which involves a context model and a flexible data acquisition policy. The context model is used for understanding the status of air pollution on the remote Place. It can provide an alarm and safety guideline depending on the condition of the context model. It also supports the flexible sampling interval change for effective the tradeoff between sampling rates and battery lifetimes. In this Pollution Map is a new automated system that monitors the air quality of urban cities and displays the information using a web service. The system collects pollution data using mobile hardware modules, transmits the data regularly using GPRS to a back-end server, and integrates the data to generate a pollution map of the city using its geographical information system. The pollution map

is available at any time from an easy-to-view website. The proposed system consists of a Mobile DataAcquisition Unit (Mobile DAQ) and a fixed Internet-Enabled Pollution Monitoring Server (Pollution-Server).

4. Methodology and Design

Sensor Deployment:

Identify suitable locations for sensor deployment, considering factors such as high human activity, proximity to pollution sources, and diverse environmental conditions.

Install a variety of sensors to measure different air quality parameters, ensuring coverage for key pollutants like PM, CO, NO2, SO2, O3, and VOCs.

Sensor Calibration:

Calibrate each sensor to ensure accurate and consistent measurements. Use calibration gases and standards to adjust sensor readings and account for variations due to environmental conditions.

Data Collection and Transmission:

Set up the microcontroller unit (MCU) to collect data from the deployed sensors regular

Establish a communication protocol (e.g., MQTT, HTTP) to transmit the collected data

Cloud Infrastructure:

Utilize cloud platforms (e.g., AWS, Azure, Google Cloud) to store and manage the incoming air quality data.

Implement a robust security mechanism to protect sensitive information and ensure data integrity.

Data Analysis:

Develop algorithms and models for real-time analysis of air quality data.

Implement anomaly detection mechanisms to identify unusual spikes or patterns that may indicate potential environmental issues.

Utilize statistical methods to generate insights and trends related to air quality over time.

Visualization:

Create a user-friendly dashboard or mobile application to display real-time air quality information and historical trends.

Include visual representations such as graphs, charts, and maps to make the data easily understandable for both technical and non-technical users.

Alert Mechanism:

Implement an alert system that triggers notifications (e.g., emails, SMS) when air quality levels exceed predefined thresholds.

Include different alert levels based on the severity of the air quality degradation.

Integration with External Systems:

Explore opportunities for integration with external systems, such as weather data or traffic patterns, to enhance the understanding of the factors influencing air quality.

Maintenance and Calibration Routine:

Establish a regular maintenance routine for sensors and the IoT infrastructure to ensure continuous and accurate operation.

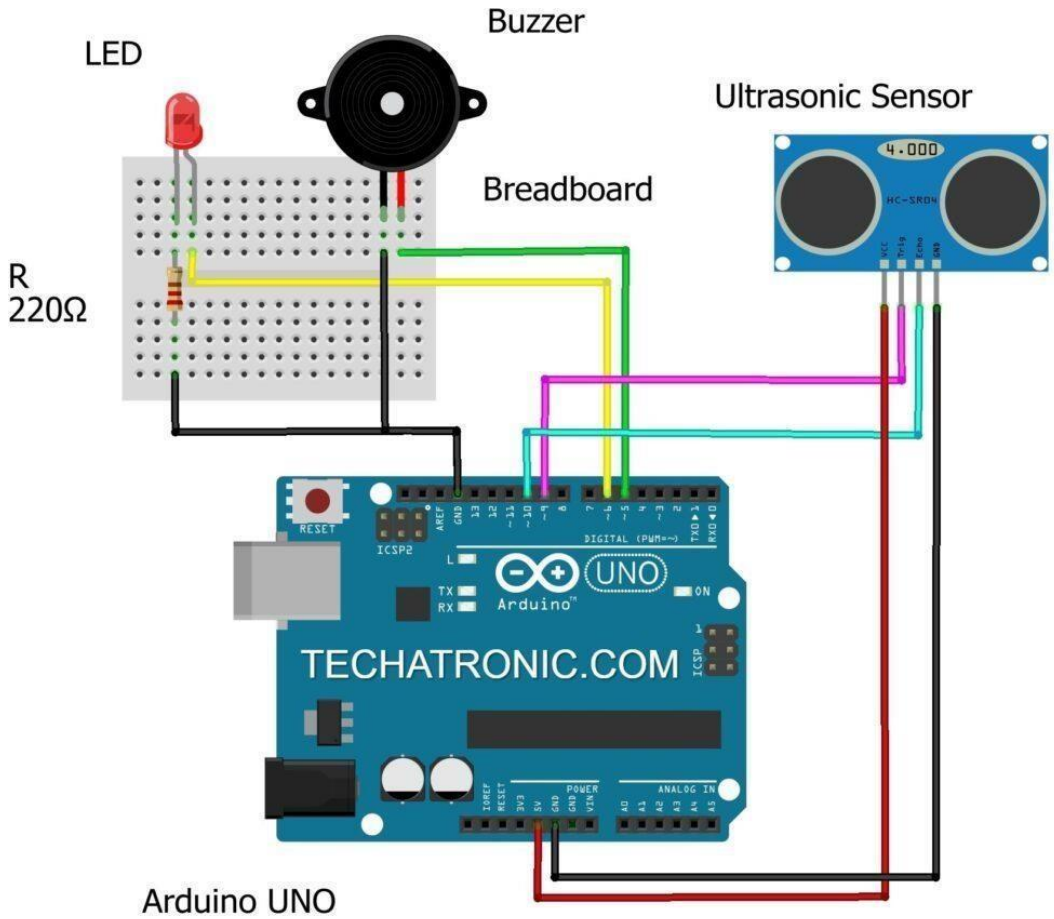
Implement automated calibration checks and alert mechanisms for sensor malfunctions or deviations.

Community Engagement:

ELECTRIC CIRCUIT:

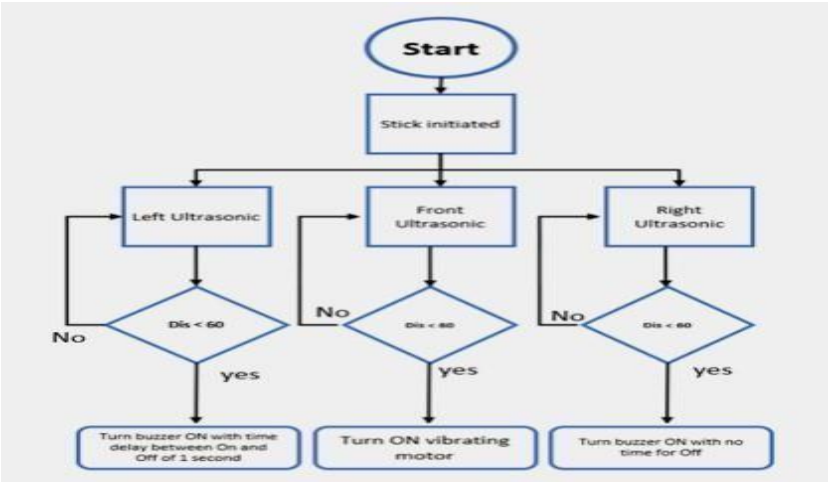
The electric circuit has been designed using Proteus software. Then the actual circuit was built using the component mentioned in the previous section. Proteus is software for designing and simulating electric circuits developed by labcenter electronics[12]. It also used for schematic capture and PCB design. Its simplicity and user-friendly design made it popular among electronics hobbyists. Proteus is commonly used for digital simulations such as microcontrollers and microprocessors. The software is

used mainly by electronic design engineers and technicians to create schematics and electronic prints for manufacturing printed circuit boards. The electric circuit of the system is shown in figure (7). It consists of three ultrasonic sensors, buzzer and a vibrating motor. According to the code that was written using Arduino IDE software. If the obstacles are on the right side, the buzzer is ON. If the obstacle is on the left side of the person, the vibrating motor is ON. If the Obstacle is from the front, both the vibrating motor and the buzzer will Be ON. To simulate the Ultrasonic sensor in this program, a special sonar sensor used, it has an extra pin that connected to a potentiometer (variable resistance), the changing the value of the resistance represents the changing in the distance for the obstacle. The sensor is shown in figure 8. The code can be uploaded to the Arduino as long as the written code by Arduino Ide software is saved as Hex. After assembling the circuit, by pressing the play option in the program, the result will be appeared. The flowchart shown in figure 9 shows how the system work.



Arduino UNO	**Ultrasonic Sensor**	
(+5V)	VCC	
GND	GND	
D9 Pin	Trig Pin	
D10 Pin	Echo Pin	
Arduino UNO	**Buzzer**	
D5 Pin	Positive Terminal	
GND	Negative Terminal	
Arduino UNO	**LED**	**220 Ohm Resistor**
D6 Pin	Anode Pin	
	Cathode Pin	Terminal 1
GND		Terminal 2

FLOW CHART:



5. Implementation:

```
const int trigPin = 9; const int
echoPin = 10; long duration;
int                distanceCm,
distanceInch; void setup()
{

Serial.begin(9600); pinMode(trigPin,
OUTPUT);          pinMode(echoPin,
INPUT);

pinMode(6, OUTPUT); // Connect LED Pin D6 pinMode(5,
OUTPUT); // Connect Buzzer Pin D5

}       void
loop() {
digitalWrite(trigPin,                    LOW);
delayMicroseconds(2);          digitalWrite(trigPin,
HIGH);                  delayMicroseconds(10);
digitalWrite(trigPin,      LOW);      duration      =
pulseIn(echoPin,          HIGH);          distanceCm=
duration*0.034/2;              distanceInch          =
duration*0.0133/2;    Serial.println("Distance:    ");
Serial.println(distanceCm); delay (100);
// See the Ultrasonic Sensor Value in Serial Monitor


if(distanceCm < 25) // You can Change the value
{ digitalWrite(5, HIGH); // Buzzer ON
  digitalWrite(6, HIGH); // LED ON
  }
else
{ digitalWrite(5,LOW); // Buzzer OFF
   digitalWrite(6,LOW); // LED OFF
}
```

}

5. Explaination

The main aim is to make new technology easier to use for visually disabled people. In a technology-controlled world where people strive to live independently, this work proposes an ultrasonic stick for blind people to aid them in achieving personal independence. It is simple to use due to its low cost and lack of bulk.

The ultrasonic sensor senses the presence of an obstruction and calculates the distance between the source and the target, a water sensor is used to detect the presence of water, and a fire sensor is used to detect the presence of fire by an alarm, vibration and sound. During the evaluation of this method, opinions on individuals with visual impairments were formed through discussions and interviews with users to identify resources designed for blind people with disabilities. The Design of a Stick Prototype for People with Visual Impairment Using Ultrasonic Esp8266 is discussed below. The views of blind people are one of the subjects addressed to receive feedback/appraisal from users. Three users were given the task of rating the prototype, as well as trying it out and responding to the statements made. Based on the findings, it can be inferred that ultrasonic sensor sticks have proven to be extremely beneficial to blind people. This prototype has reduced the risk of blind people getting into accidents in difficult road structures with many obstacles, as well as when crossing the street. Since a large gap between the stick and the sensor can result in constant censorship of objects recognized around the stick, the design of the blind stick is made more flexible on the stick section, which is something to consider. The stick works by creating an Android-based mobile application that links the stick to the phone and performs a variety of tasks, including making phone calls to pre-determined numbers and determining the location. The stick is distinguished by its low price and simple nature. When the wireless sensor detects an object or obstacle in its environment, it serves as an input or input to the esp8266 processor. The audio jack connected to the headphone then emits sound. The lack of essential skills and preparation, as well as the limited range of motion and knowledge transmitted, are among the most serious shortcomings of these aids. Electronic assistive devices are intended to solve issues like these, and we used some electronics modules and sensors to adjust the cane. A buzzer, ultrasonic sensors, and a water sensor are all included. The blind person walking with an electronic stick.

Two ultrasonic sensors are mounted on the stick having a set to different ranges for avoiding small obstacles. Three push buttons that can be operated with the thumb allows the blind user to send a general message (I am in trouble, help me) on a saved mobile no, or make a call for help. Vibrating sensors along with a buzzer used for beep and vibration if the stick is about to hit any obstacle. The circuit box contains a combination of microcontroller circuitry. The co-operation between the Ultrasonic and others sensors are utilized to create a complementary system that can give reliable distance measurement. A schematic circuit is made to make it easier to make tools. The schematic consists of Esp8266, Battery, Ultrasonic Sensor, water sensor. The ultrasonic sensors in our proposed project are used to detect obstacles ahead using ultrasonic waves. When the sensor detects obstacles, it sends the information to the Esp8266. The Esp8266 then analyzes the information and determines if the obstacle is near enough. If the obstacle isn't near enough, the circuit has no impact. If the obstacle is approaching, the Esp8266 issues a voice warning. It also senses water and warns the blind by sounding. The vibrator is also included in the stick. If the obstacle is approaching, the Esp8266 vibrates to alert you. A water sensor is used to sense water. V. SYSTEM DESCRIPTION A. Ultrasonic Sensor It is an ultrasonic sensor, also known as an ultrasonic transducer, that is based on a transmitter and receiver and is primarily used to determine the distance from a target object with a wavelength ranging from 20kHz to 20 MHz [5]. Ultrasonic sensors, like sonar detectors, work by transmitting a pulse of sound outside the range of human hearing. At the speed of sound (340 m/s), this pulse travels away from the range finder in a conical shape. The sound bounces off an object and is reflected in the range finder. This is interpreted as an echo by the sensor, which measures the time between transmitting the signal and receiving the echo.

PRINCIPLE OF OPERATION :

The System Development Life Cycle (SDLC) is the process of developing and changing processes, as well as the models and methodologies used to construct an application and a software development process[3]. It involves the following steps:

A. Preparation: Needs evaluations, feasibility studies (both scientific and technological), and scheduling are also carried out as part of the planning phase.

B. Analysis: Direct observation is used during the research process to look at the problems that arise and are found in the materials, software, and hardware.

C. Design: At this point, the application will be explained in detail regarding the design phase of each component in the prototype under the needs addressed earlier in the prototype[4].

D. Implementation: The code is brought to life at this stage by selecting components and planning the software (coding/coding).

E. Testing: Testing is carried out at this point to see if the framework created satisfies the user's needs; if it does not, the next phase is iterative, i.e. returning to the previous stages. And the test is designed to identify and eliminate flaws in the device so that it can truly assist users in their everyday activities.

F. Maintenance: The system's operation starts at this stage, and minor repairs can be made if necessary

SCREENSHOTS:

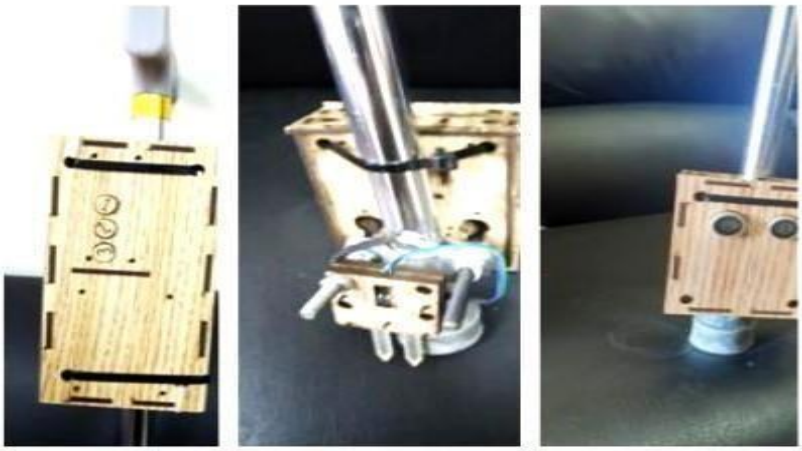
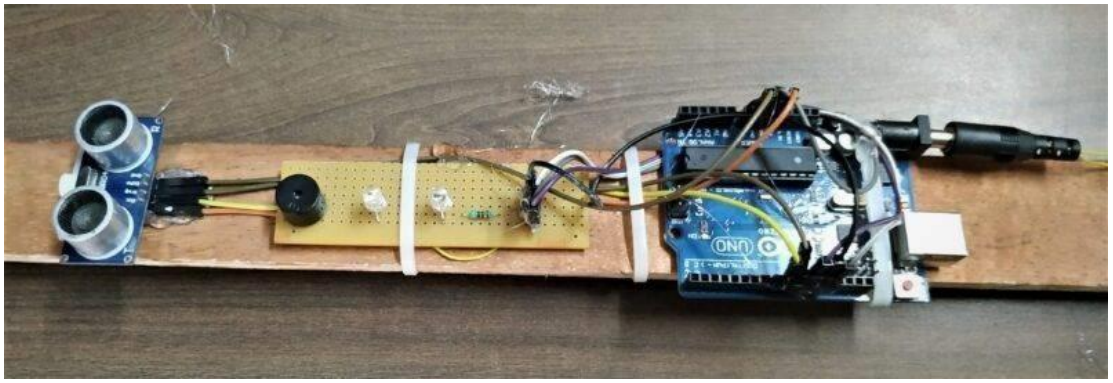
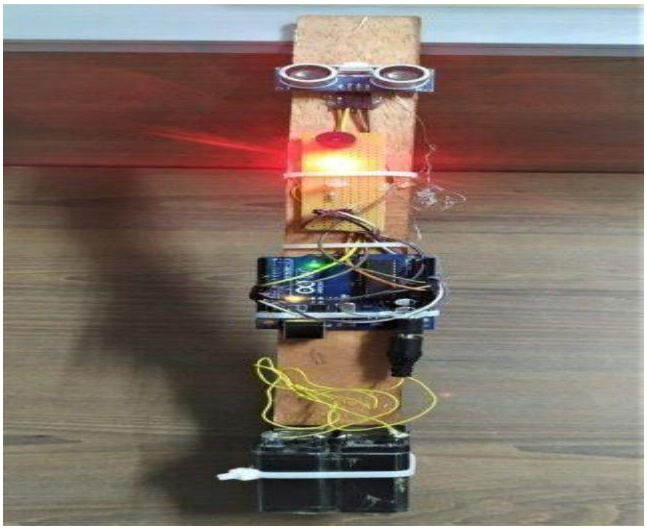


Fig.5.a. Three push boutton

Fig.5.b. Water Sensor

Fig.5.a. Ultrasonic Box



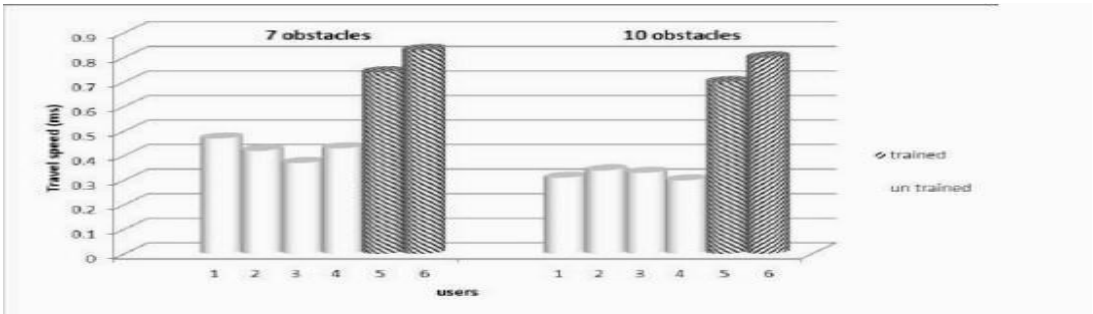


RESULT:

It is to be observed that when all the sensors detect at the same time both buzzer and vibrating motor (work simultaneity) except that the buzzer delay between on and off is less than previous cases. The whole idea of using three sensors is to detect a wide range of area that could make the person move freely quite simple, with low cost, and more safety for both indoor and outdoor applications. In the Middle East countries such as Iraq, there is a huge need for a low-cost solution for blind people. That is why most people can have a reliable, low cost, and an accurate device as presented in this paper. The table below shows the result of the working system.

Air quality detection

Sensor	The actual distance	The distance with the buzzer	Error %	Actuator
Right	70 cm	69.4 cm	0.85%	Buzzer
Left	70cm	69.95cm	0.07%	Motor
Front	70cm	70 cm	0%	Buzzer and Motor



Conclusion:

In this project IoT based on measurement and display of Air Quality Index (AQI), Humidity and Temperature of the atmosphere have been performed. From the information obtained from the project, it is possible to calculate Air Quality in PPM. The disadvantage of the MQ135 sensor is that specifically it can't tell the Carbon Monoxide or Carbon Dioxide level in the atmosphere, but the advantage of MQ135 is that it is able to detect smoke, CO, CO2, NH4, etc harmful gases. After performing several experiments, it can be easily concluded that the setup is able to measure the air quality in ppm, the temperature in Celsius and humidity in percentage with considerable accuracy. The results obtained from the experiments are verified through Google data. Moreover, the led indicators help us to detect the air quality level around the setup. However, the project experiences a drawback that is it cannot measure the ppm values of the pollutant components separately. This could have been improved by adding gas sensors for different pollutants. But eventually, it would increase the cost of the setup and not be a necessary provision to monitor the air quality. Since it's an IOT-based project, it will require a stable internet connection for uploading the data to the ThinkSpeak cloud. Therefore, it is possible to conclude that the designed prototype can be utilized for air quality, humidity and temperature of the surrounding atmosphere successfully.

10. Future Enhancement

Future scope involves providing more security when it comes to connecting to the system and data collected. More sensors can be added to the system, such as gas sensors, to determine levels of pollutants such as NO2, SO2 and others. Also, use of Big Data Analysis to analyse the collected data when number of users increases. The data obtained by the devices of all the users can be consolidated, analysed and then

displayed on a web application that can be accessed by anyone. More statistics can be provided to get deeper insights into the collected data. The gathered data helps the users to take precautions while travelling across highly polluted areas or to avoid visiting those regions. The data can be further supplied to the concerned authorities to take right measures to reduce pollution levels at the identified locations.

11. References

[1] Yamunathangam, K. Pritheka, P. Varuna, IOT Enabled Air Pollution Monitoring and Awareness Creation System, International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-7 Issue-4S, November 2018

[2] Mohamed Firdhous, Bh Sudantha, Pathmasiri Karunaratne, IoT enabled proactive indoor air quality monitoring system for sustainable health management -

[3] Giovanni B. Fioccola, Raffaele Sommese, Imma Tufano, Roberto Canonico and Giorgio Ventre, Polluino: An Efficient Cloud-based Management of IoT Devices for Air Quality Monitoring

[4] Manju K. Chattopadhy, An IoT Based Low Cost Air Pollution Monitoring System

[5] Moshammer Hanns, Communicating health impact of air pollution

[6] Pallavi Pant & Raj M. Lal & Sarath K. Guttikunda & Armistead G. Russell & Ajay S. Nagpure & Anu Ramaswami & Richard E. Peltier, Monitoring particulate matter in India: recent trends and future outlook

[7] Vijayakumar Sajjan, Pramod Sharma, Research on an Iot Based Air Pollution Monitoring System, International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-8, Issue- 9S2, July 2019

[8] Giovanna Ranalli, Giorgia Rocco, Giovanna Jona Lasinio, Beatrice Moroni, Silvia Castellini, Stefano Crocchianti, David Cappelletti, 'Functional exploratory data analysis for high-resolution measurements of urban particulate matter', In Biometrical Journal 58 (2016) 5,1229–1247, DOI: 10.1002/bimj.201400251

[9] Jill Engel-Cox, Nguyen Thi Kim Oanh, Aaron van Donkelaar, Randall V. Martin, Erica Zell, 'Toward the next generation of air quality monitoring: Particulate Matter', In Atmospheric Environment Volume 80, December 2013, pp. 584-590

[10] Abdulrahman Abdullah Alkandari, Samer Moein, 'Implementation of Monitoring System for Air Quality using Raspberry PI: Experimental Study', In Indonesian Journal of Electrical Engineering and Computer Science, ISSN: 2502-4752, DOI: 10.11591/ijeecs.v10.i1.pp43-49 Volume-10, No.1, pp. 43 49, April 2018