

Original Research Article

DESIGN AND IMPLEMENTATION OF IOT BASED UBIQUITOUS WEATHER STATION

ABSTRACT

Pollutants emitted into the atmosphere, including atmospheric ozone, which raises the temperature, contribute to climate change. This could have an impact on local air quality. The temperature can be heated or cooled by other PM components, though. Headaches, heart illness, respiratory problems, acid rain, fever, and other symptoms can be caused by weather and environmental pollution, which can harm both people and the ecosystem. With this research, scientists hope to construct a smart sensor to monitor our environment's exposure to weather and environmental contaminants. By creating an interface between data collecting monitoring equipment that interfaced with a website and analysis software, this was made possible. In accordance with the WHO (World Health Organization) standard, the online portal records and analyzes the measured data from the monitoring device. It also compares the measured data at different locations. This project's main microcontroller is an Arduino UNO. An Arduino UNO microcontroller is used to collect data from the system's embedded sensors. The data is converted to a text file using the Arduino serial connection and the CoolTerm application. The system keeps tabs on environmental changes including temperature and precipitation. The data is shown as graphical statistics on the web site's design in the form of information on the web portal.

In addition to the production powerhouse, offices on the Federal Polytechnic Ile Oluji campus are used to test the equipment. Each dataset was prepared in three minutes and then compared

to the WHO standard. According to the findings, people who live near generators face a greater danger to their health.

Keywords: Arduino UNO, Microcontroller, CoolTerm application, Web portal

INTRODUCTION

According to the Environmental Protection Agency (EPA), pollution occurs when the earth/atmosphere system's physical and biological components are contaminated to the degree where normal environmental processes are affected. Toxic gas emissions from industry, vehicular emissions, and increased levels of hazardous gases and particulate matter are polluting the air. Industries, urbanization, a growing population, and automobile use are all contributing to an increase in pollution that is damaging to human health. As a result, real-time air quality monitoring is required to make appropriate decisions in a prompt manner. Car emissions and generator smoke, for example, are major contributors to the current rise in air pollution. It is necessary for humans to have an adequate standard of living, but numerous sensors can detect air quality, therefore a decent metric is needed to expose the intensity level of air pollution, whether it is low, medium, or high. The corresponding values can be used to make another choice about the data. Using IoT, sensors may now communicate with the cloud, where data is stored in the MYSQL database and retrieved from any computer with an internet connection. The data is collected from an Arduino serial monitor by clicking on its com port and then stored in the CoolTerm application. Data collection on temporal dynamics of weather changes is vital for human survival since weather monitoring is critical. The Arduino UNO, CoolTerm software, and various weather sensors, such as the DHT-11, MQ-135, sound sensor, and others, are used in this Internet of Things project to monitor the weather conditions. The Internet of Things provides the power for this weather station (the internet of things). In order to know the status of weather conditions, it is equipped with

environmental sensors that collect and distribute polluted gases in a specific location and report them in real time on the cloud. The user can check the weather station webpage to see the live results, or they can be sent as an SMS message to a user or individual at a specific time interval. Measured data can be accessed from anywhere in the globe using Internet-enabled devices. Using sensors, an internet connection is used to collect and transmit weather data to a remote web server in real time. In the cloud, the weather parameters are uploaded for real-time weather reporting and a graphical representation of the weather data.

LITERATURE REVIEW

Karthigaeni and Nithyalakshmi (2020) used Blynk Server to build a Wireless Weather Monitoring System based on the Internet of Things. This project describes a wireless weather monitoring system based on the internet of things (IOT). Weather monitoring is used not only in agriculture, but also in the industrial sector. The methodology describes four basic parameters: temperature, soil moisture, humidity, and vibration level. Users can use their smartphones to obtain any information that is available via an internet connection.

Dorevi and Dankovi (2019) built a sensor-powered Smart Weather Station. The system uses internet of things technology to record measured data and allows the user to examine the information at any time and from any location. The system is based on a collection of embedded sensors, a Peripheral Interface Microcontroller (PIC) microcontroller serving as the system's core and server, and wireless internet access via the Global System for Mobile Telecommunications (GSM) module using the General Packet Radio Service (GPRS) communication protocol.

Prasanna et al. (2019) developed an Intelligent Weather Monitoring System using the Internet of Things. The data is sent to the cloud, where it may be accessed via the internet from anywhere. The system employs sensors to manage and monitor environmental factors such as

temperature, pressure, smoke, relative humidity level, and a variety of other gases, and then sends the data to the cloud and plots the sensor data graphically.

Ngebani and associates (2018) Make a Weather Station for the Internet of Things Making use of a microcontroller. Data from environmental sensors is sent to ThingSpeak, a cloud-based IoT platform. The primary reason for moving data to a server is to enable access to it from anywhere in the world at any time of day. Sensors and circuits assemble and show environmental parameters such as temperature, relative humidity, humidity, light intensity, and carbon monoxide levels.

Musa and Bashir (2018) developed a mobile weather monitoring system based on a microcontroller. A weather monitoring device is programmed to measure and display the air temperature, pressure, relative humidity, solar radiation, and wind speed. The purpose is to create and deploy a mobile weather monitoring system that can be accessed remotely. An Anemometer (wind speed sensor), a DHT11 (temperature and relative humidity sensor), an MPX5100AP (pressure sensor), an LDR (Light Dependent Resistor) for light intensity, a microcontroller, and a Memory Card were all used (MMC). A weather monitoring system was installed, and it was utilized to monitor and save five weather parameters on a memory card.

Kumar and Jasuja (2017) created an IoT-based Urban Climate Monitoring System using the Arduino Uno. The system is based on cloud computing and the Internet of Things. The Internet of Things (IoT) is a network of internet-connected objects that can collect and exchange data through the use of embedded sensors. The system employs a low-cost Arduino Uno Board, which records data from multiple sensors and sends it to the cloud via an Ethernet shield. The real-time data that is posted to the cloud may be viewed in labelled data

and graphs at any time by using the Blynk software, which comes preinstalled on Android and iOS-based mobile phones with internet connectivity.

Mahmood and Hasan (2017) built a weather monitoring system using an Arduino database implementation.

This study largely merges two-study field-based control systems and data collection methodologies to create a database system based on the qualities utilized to generate the provided data.

Muchovo (2016) designed and built a gsm-based weather station. This project seeks to build a simple, low-cost remote weather station that measures weather conditions using sensors to measure temperature, humidity, air pressure, rainfall received, and light intensity, displays them on an LCD, and communicates them to a remote user through SMS. The Arduino Uno, the SIM900 GPRS/GSM shield, an LCD, temperature, humidity, atmospheric pressure, and light intensity sensors were used to build this project.

Design Analysis

Description of Components

1 Arduino Uno

As can be seen in Figure 2.1, an Arduino Uno was used as the project's microcontroller. The ATMEGA328P microcontroller board is used in the construction of this device, which makes use of Atmel's high-density nonvolatile memory technology. IDE support for C and C++ programming languages is built-in to Arduino's software development kit (SDK). In total, there are 16 pins on the board: 14 are digital and 6 are analog. Via the Arduino IDE, it may be programmed using a type B USB port (Integrated Development Environment). USB cable

or external 9-volt battery power the device, which accommodates voltages between 7 and 20 volts.



Figure 2.1: Arduino Uno

2 CoolTerm Application

Figure 2.2 depicts Roger Meier's CoolTerm, a cross-platform serial console program. It has all the functionality you'll need to communicate with hardware devices, and it looks great doing it. Servo controllers, robotic kits, GPS receivers, and other microcontrollers with serial ports may all use CoolTerm, which is designed for hobbyists and professionals who need to share data with them.

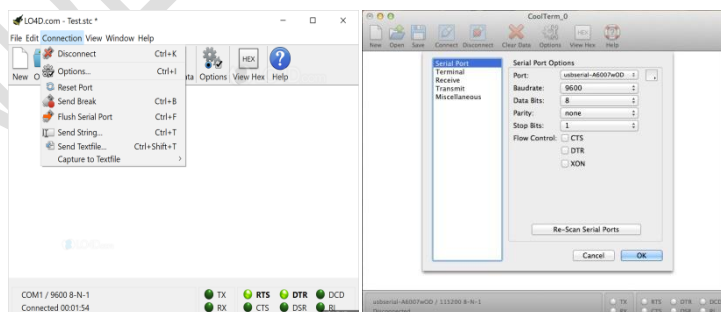


Figure 2.2: CoolTerm Application

3 Temperature and Humidity Sensor (DHT11)

Figure 2.3 shows the DHT11 sensor, which is a combination of a temperature sensor and a humidity sensor. An 8-bit microcontroller is linked to a resistive wet component sense and an NTC temperature measurement device on the sensor.



Figure 2.3: DHT-11

4 MQ135 Sensor

While the MQ135 gas sensor is highly sensitive to CO₂, sulfide, carbon monoxide, and ethanol, as well as smoke and other dangerous gases, this project concentrates on CO₂ and sulfide alone. It is a low-cost option that may be used in a variety of ways. SnO₂ is used to make this delicate substance, and in pure air, it has a reduced conductivity. The sensor's conductivity increases along with the gas concentration when it detects the presence of the flammable target gas. Figure 2.4 depicts MQ-135 in all its glory.



Figure 2.4: MQ-135

5 Sound Sensor

Figure 2.5 shows a sound sensor that measures the decibel level, or how soft or loud a sound is. The Sound Sensor can distinguish between decibels (dB) and decibels (dBA). The amount of sound that can be detected by human ears is measured in decibels (dBA). For comparison's sake, a noise level of 4% is comparable to a quiet living room, while a noise level of 5–10% is comparable to someone conversing far away. A regular discussion or music played at a moderate volume is represented by 10%-30%, whereas yelling and music played at excessive decibels are represented by 30%-100%.



Figure 2.5: Sound Sensor

6 UV Light Sensor

When used in certain applications, the UV sensor, which is also known as an Ultraviolet light sensor, has the ability to measure the UV index. The UV light from the sun will be measured with ML8511 as part of this project. The ML8511 is an ultraviolet light meter with a 365nm wavelength. The voltage generated by the sensor is directly proportional to the UV light's intensity. The supply voltage is 3.0V, however a 3.3V supply will be used in the system now under development. Figure 2.6 depicts UV light.



Figure 2.6: UV Light Sensor

7 Lcd Screen

An LCD screen shown in figure 2.7 is an electronic display module that uses liquid crystals to produce a visible image. The 16×2 LCD is an introductory module commonly used in DIYs and circuits. The 16×2 translates and display 16 characters per line in 2 such lines. In LCD, each character is displayed in a 5×7-pixel matrix and has 16 columns and two rows. An Interface IC like HD44780 is used, mounted on the backside of the LCD Module itself. The function of this IC is to get the Commands and Data from the MCU and process them to display meaningful information on the LCD Screen. It operates at a voltage between 4.7V to 5.3V while the Current consumption is 1mA.



Figure 2.7: LCD Screen

Eight 12C Module

An easy-to-use display module, like the one illustrated in figure 2.8, can make using the display a lot easier. It can make things easier for makers so they can concentrate on what they do best. PCF8574 I2C chip converts I2C serial data to parallel data for the LCD when plugged into a computer. The I2C addresses for these modules are currently 0x27 or 0x3F, depending on the model. Check the black I2C adaptor board on the module's underside to see which version you have. It is powered by a 5V battery.



Figure 2.8: I2C module

Figure 3.1 depicts the system's block diagram. The ATMEGA 328p microcontroller is connected to the sensors via the digital and analogue pins of the Arduino UNO, the project's primary microcontroller. Input data from the sensors is sent to the microcontroller, which uses it as an input and shows the results on the serial monitor of the Arduino board once processing is complete. The LCD screen presented the sensor data that was being displayed on the display device. The computer system provides the voltage needed to power the LCD and the rest of the system. Atmel ATMEGA328 reading data from DHT-11, MQ-135, Sound and UV light sensors and converting it into a text file for the CoolTerm application, which is subsequently entered into the MYSQL database by PHP routines. The ATMEGA328 microcontroller is used

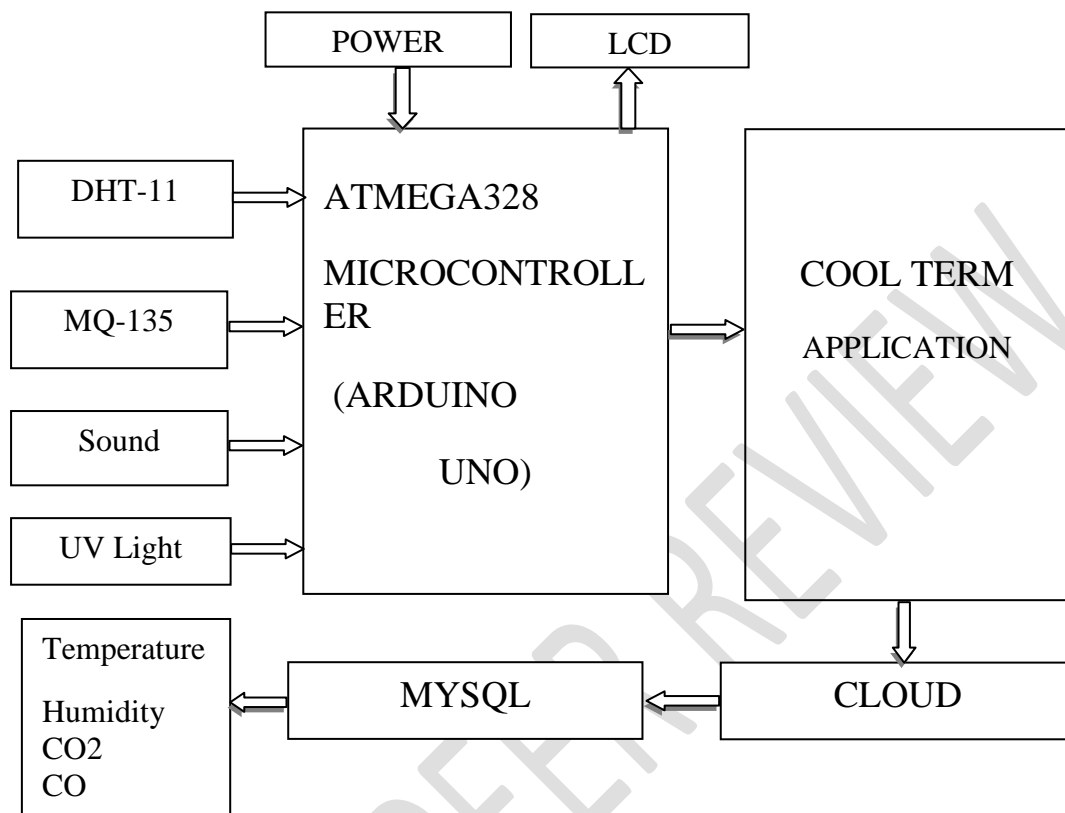


Figure 3.1: The System Block Diagram

Circuit diagram

Using Proteus professional software, a PC running Windows 10 was used to construct the circuit schematic. Pictured in figure 3.2 is a Proteus schematic and diagrammatical depiction. The Arduino microcontroller is used to collect data from a variety of sensors on various pins. Multiple sensors are connected to the microcontroller, with the exception of those that require 3.3V or use a 3.3V pin out from the board to take 5V input from Arduino Uno. The computer system powers the sensors while the microcontroller is powered by it. It's possible to use either the 3.3v or the 5v Arduino board with these sensors because they have three terminals. The Arduino board's GND pin connects to the board's ground terminal, while the Data pin connects to a digital or analogue pin to allow data to be sent. A2 on the Arduino board is used

to connect the UV light and UV sensor. Digital pin 2 on the Arduino board is used to link the DHT-11, MQ135 and sound sensor. The DHT-11 is powered by a 3.3 volt battery. 5 volts power is used for MQ1235, the sound sensor voltage, and the UV light. A 5 volt battery powers the LCD. LCD display. Sensors connected to a breadboard need a 5 volt power supply.

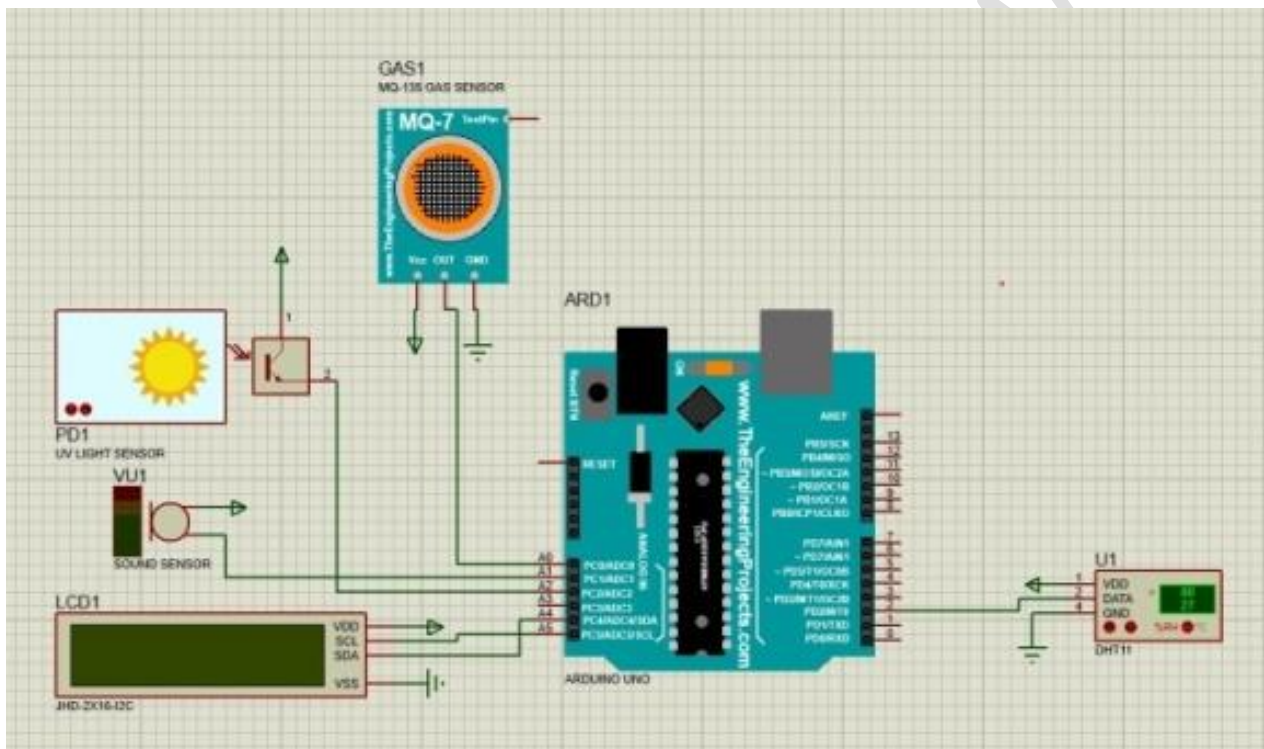


Figure 3.2: Proteus circuit diagram design

Flowchart Algorithm

It shows the operational flow of communication and data transfer between the Arduino Uno and the sensors, i.e. how data is transmitted from the sensors to the webpage, in Figure 3.3.

The system design flowchart

Step 1: Start

Step 2: Weather sensors sense the atmospheric condition in the environment

Step 3: Microcontroller check the sensor codes and libraries

Step 4: If the libraries and codes are correct, data is displayed on the serial monitor and LCD

Step 5: CoolTerm application convert the data displayed on the serial monitor into a text file by Connecting it with the COM port

Step 6: Converted text file will be called using PHP and insert the content into the database.

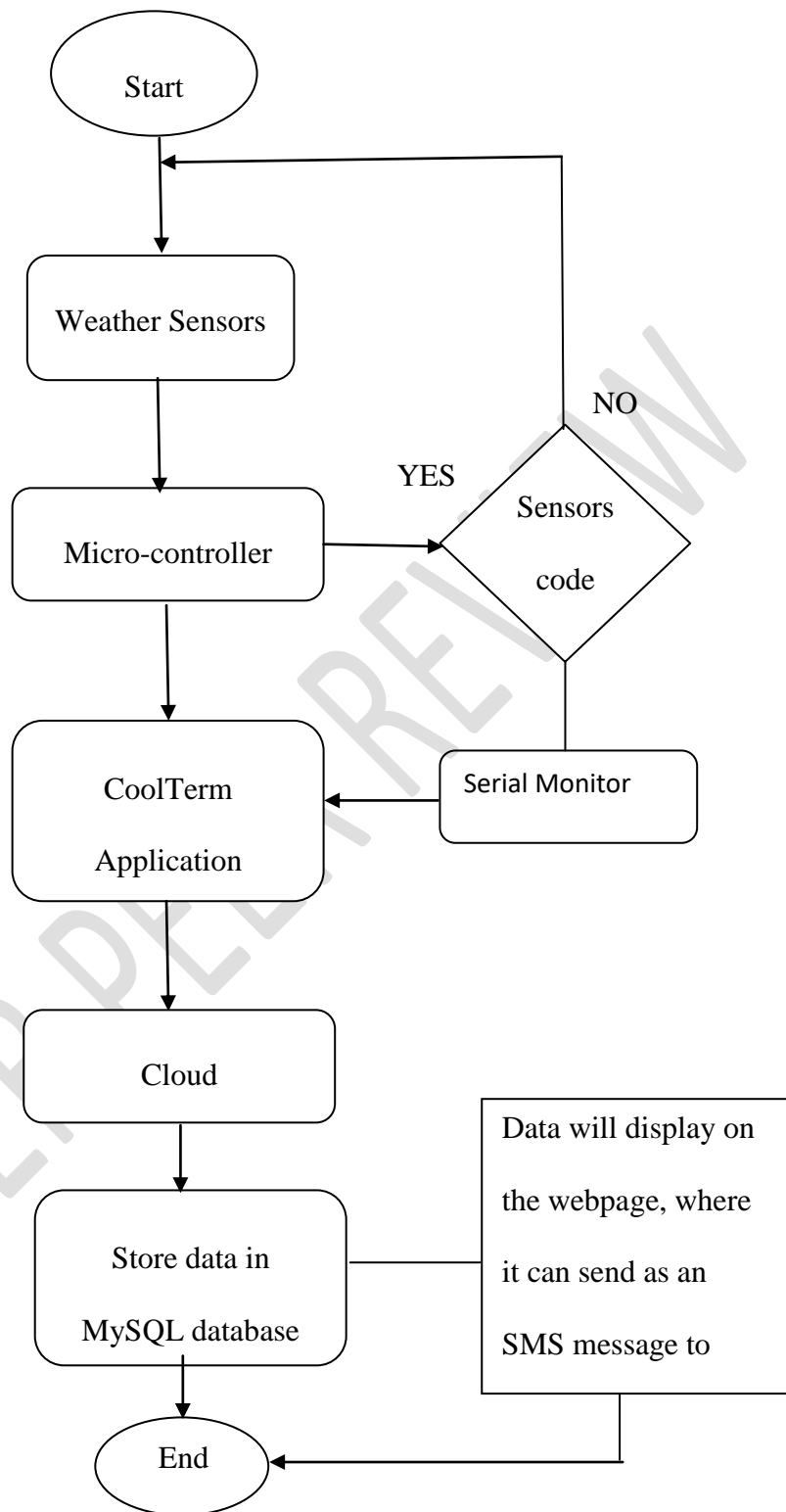


Figure 3.3: Flowchart of the System

3.4.2 Webpage Development

It was created utilizing a variety of tools, including the sublime text editor as well as bootstrap, HTML, CSS, and PHP. The website may be seen in Figures 3.4 through 3.8. When the webpage is loaded, a connection to the web server is made to the folder containing the recorded files, and then the measured data is shown on the webpage. The graph, bar chart, and pie chart are all available as PDF downloads. The data can be given to users by SMS message from the admin panel. The website allows visitors to view the daily readings from the instruments via a secure login.



Figure 3.4: Front page of weather website with daily results

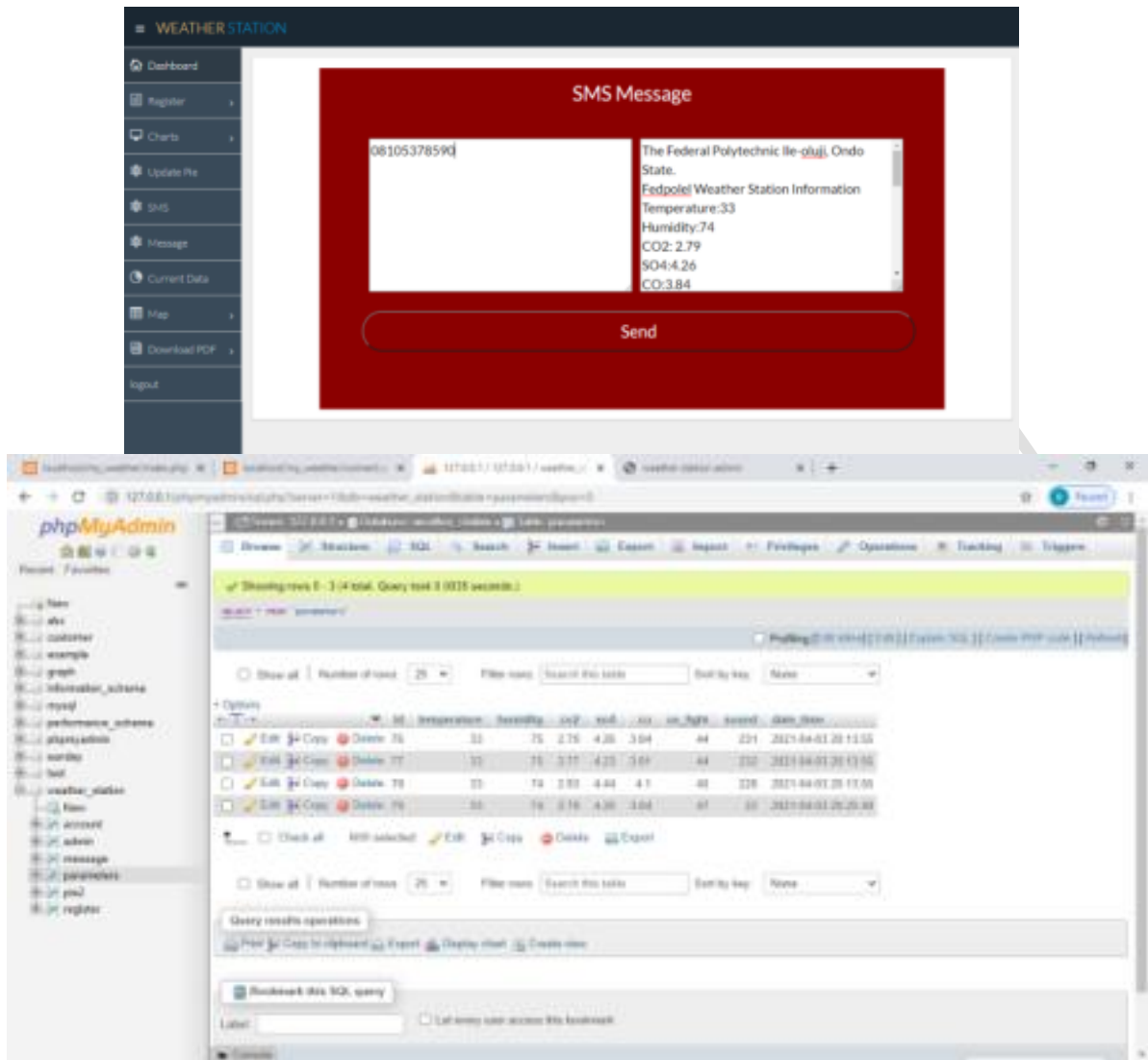


Figure 3.5: SMS page and database weather data

RESULT AND DISCUSSION

Hardware packaging

Figure 4.1 depicts the project's hardware setup. The Arduino Uno is connected to the components, which are then enclosed in an adaptable box to keep them safe from outside disturbance.



Figure 4.1: Components arrangement in the Adaptable box

Testing and Result

The generating point was tested at the Federal Polytechnic of Ile Olunji in Ogun State's academic take-off, permanent site, engineering building, and educational environment. Climate change and pollution are assessed using data collected from a variety of locations

and compared to WHO guidelines. Table 4.1 shows the WHO standard, dangerous values, and items that conform to those values and values.

UNDER PEER REVIEW

Table 4.1: W.H.O Standard and their harmful values

PARAMETERS	WHO STANDARD	HARMFUL VALUE	EFFECTS
Temperature	36.5°C - 37.2°C	40°C	Heat cramps, Fever, Feeling and death
Humidity	30% - 60%	61%	Overheating, Uncomfortable etc.
Carbon(iv)oxide	250ppm – 400ppm	500ppm and above	Headache, Dizziness, Difficulty in breathing.
Sulfide	200ppm – 250ppm	250ppm above	Acidic rain
Carbon monoxide	50ppm – 100ppm	150ppm above	Reduction in the flow of blood in the body, HeadacheHeadache.
Sound	30dB – 69Db	70dB above	Difficulty in hearing, High blood pressure, Heart diseases, Lack of sleep.
UV Light	0 – 5	8	Ageing of the skin, Eye problems and Skin cancer.

4.2.1 Generated Values for 3 minutes at different locations on the campus

```
COM9  
|  
|  
Calibrating please wait..... done!.  
THE SENSORS TAKE READINGS EVERY 3mins  
  
Temperature|Humidity|CO2|SO4|CO|UV light|S  
31.70;70.00;2.49;3.86;3.28;90.00;424.00  
31.70;70.00;2.53;3.92;3.36;91.00;425.00  
31.70;70.00;2.57;3.96;3.42;90.00;425.00  
31.80;70.00;2.61;4.02;3.51;92.00;426.00  
31.80;70.00;2.61;4.02;3.51;89.00;426.00  
31.80;70.00;2.63;4.04;3.54;86.00;426.00  
31.90;70.00;2.63;4.04;3.54;91.00;426.00  
31.90;70.00;2.68;4.11;3.63;91.00;427.00  
31.90;71.00;2.65;4.07;3.57;91.00;429.00  
31.90;71.00;2.55;3.94;3.39;86.00;426.00  
31.90;72.00;2.50;3.88;3.31;127.00;425.00  
31.90;71.00;2.50;3.88;3.31;113.00;425.00  
32.00;71.00;2.55;3.94;3.39;111.00;426.00  
32.00;70.00;2.55;3.94;3.39;143.00;425.00  
32.10;70.00;2.57;3.96;3.42;134.00;425.00  
32.10;69.00;2.57;3.96;3.42;134.00;425.00  
32.20;69.00;2.55;3.94;3.39;129.00;425.00  
32.30;69.00;2.53;3.92;3.36;123.00;425.00  
32.30;69.00;2.53;3.92;3.36;113.00;425.00  
32.30;69.00;2.58;3.98;3.45;109.00;425.00  
32.30;69.00;2.60;4.00;3.48;115.00;426.00  
32.30;68.00;2.57;3.96;3.42;116.00;425.00  
32.30;68.00;2.57;3.96;3.42;114.00;424.00  
32.30;68.00;2.57;3.96;3.42;114.00;424.00  
32.30;68.00;2.57;3.96;3.42;114.00;426.00  
32.30;68.00;2.57;3.96;3.42;113.00;424.00
```

```
COM9  
|  
|  
Calibrating please wait..... done!.  
THE SENSORS TAKE READINGS EVERY 3mins  
  
Temperature|Humidity|CO2|SO4|CO|UV light|So  
30.50;73.00;2.51;3.89;3.32;103.00;441.00  
30.40;73.00;2.50;3.87;3.30;104.00;441.00  
30.50;73.00;2.48;3.85;3.27;98.00;439.00  
30.50;73.00;2.44;3.79;3.19;97.00;437.00  
30.50;73.00;2.42;3.77;3.16;95.00;436.00  
30.50;72.00;2.44;3.79;3.19;94.00;436.00  
30.50;72.00;2.48;3.85;3.27;94.00;437.00  
30.50;72.00;2.51;3.89;3.32;94.00;438.00  
30.50;72.00;2.53;3.91;3.35;94.00;439.00  
30.50;72.00;2.53;3.91;3.35;93.00;439.00  
30.50;72.00;2.56;3.95;3.41;93.00;439.00  
30.50;72.00;2.54;3.93;3.38;93.00;439.00  
30.60;73.00;2.56;3.95;3.41;93.00;439.00  
30.50;73.00;2.56;3.95;3.41;99.00;440.00  
30.60;73.00;2.58;3.97;3.44;167.00;439.00  
30.60;73.00;2.58;3.97;3.44;172.00;440.00  
30.80;72.00;2.58;3.97;3.44;105.00;439.00  
30.90;72.00;2.59;3.99;3.47;95.00;440.00  
31.10;73.00;2.58;3.97;3.44;169.00;438.00  
31.30;72.00;2.61;4.01;3.50;180.00;439.00  
31.40;72.00;2.64;4.06;3.56;101.00;439.00  
31.60;72.00;2.66;4.08;3.59;99.00;440.00  
31.70;71.00;2.67;4.10;3.62;99.00;441.00
```


Table 4.2: Highest and Lowest Point of Data Measured at 3 Locations

PARAMETERS	LOCATION 1		LOCATION 2		LOCATION 3	
	HIGHEST POINT	LOWEST POINT	HIGHEST POINT	LOWEST POINT	HIGHEST POINT	LOWEST POINT
Temperature	30.70	30.40	32.30	31.70	32.20	30.60
Humidity	73.00	71.00	72.00	68.00	72.00	68.00
Carbon(iv)oxide	2.67	2.42	68.00	49.00	2.79	2.53
Sulfide	4.10	3.77	4.11	3.86	4.25	3.91
Carbon monoxide	3.62	3.16	3.63	3.28	3.83	3.35
Sound	4.41	4.36	429.00	424.00	428.00	417.00
UV Light	104.00	93.00	143.00	86.00	89.00	80.00

Table 4.3: Comparison of Lowest Point Data with the W.H.O Standard

PARAMETERS	WHO STANDARD	HARMFUL	LOWEST POINT			EFFECTS
			LOCATION 1	LOCATION 2	LOCATION 3	
Temperature	36.5°C - 37.2°C	40°C	30.40	31.70	30.60	None
Humidity	30% - 60%	61%	71.00	68.00	68.00	Uncomfortable
Carbon(iv)oxide	250ppm – 400ppm	500ppm and above	2.42	49.00	2.53	None
Sulfide	200ppm – 250ppm	250ppm	3.77	3.86	3.91	None
Carbon monoxide	50ppm – 100ppm	150ppm	3.16	3.28	3.35	None
Sound	30dB – 69Db	70dB above	4.36	424.00	417.00	None
UV Light	0 – 5	8	93.00	86.00	80.00	None

Table 4.4: Comparison of Highest Point Data with the W.H.O Standard

PARAMETERS	WHO STANDARD	HARMFUL	HIGHEST POINT			EFFECTS
			LOCATION 1	LOCATION 2	LOCATION 3	
Temperature	36.5°C - 37.2°C	40°C	30.70	32.30	32.20	None
Humidity	30% - 60%	61%	73.00	72.00	72.00	Uncomfortable
Carbon(iv)oxide	250ppm – 400ppm	500ppm and above	2.67	68.00	2.79	None
Sulfide	200ppm – 250ppm	250ppm above	4.10	4.11	4.25	None
Carbon monoxide	50ppm – 100ppm	150ppm above	3.62	3.63	3.83	None
Sound	30dB – 69Db	70dB above	4.41	429.00	428.00	None
UV Light	0 – 5	8	104.00	143.00	89.00	None

4.3 SMS Message to Mobile Phone and Graphical results

The message is sent to a mobile phone that has a registered SIM. Once the button is clicked on the webpage, the content of the message will be delivered to the phone number entered in the text box.

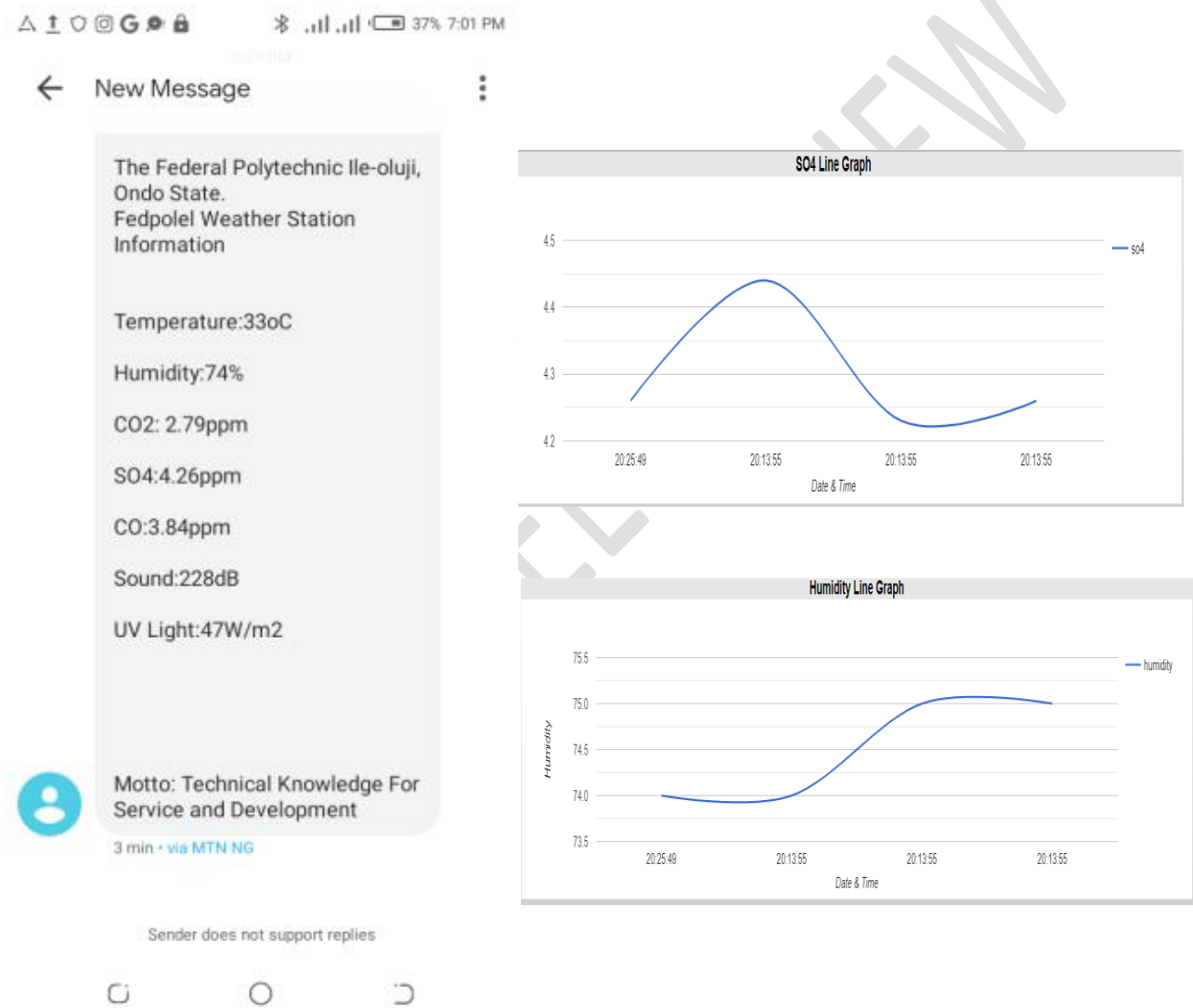


Figure 4.3: SMS message sent to mobile phone Humidity and SO₄ daily results

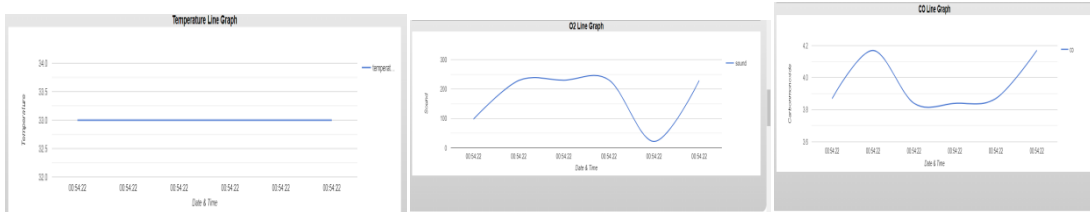


Figure 4.4: Temperature, Sound and CO daily results

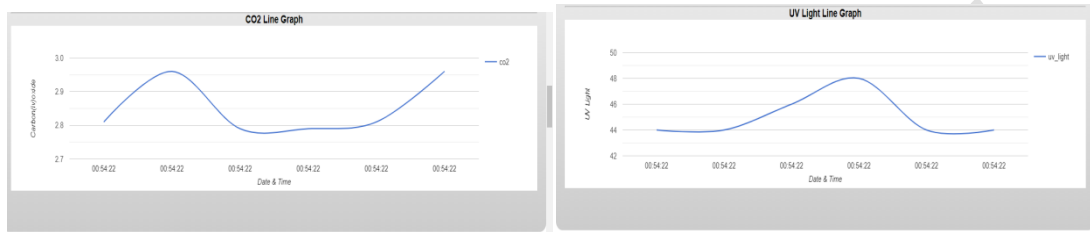


Figure 4.5: CO2 and UV Light daily results

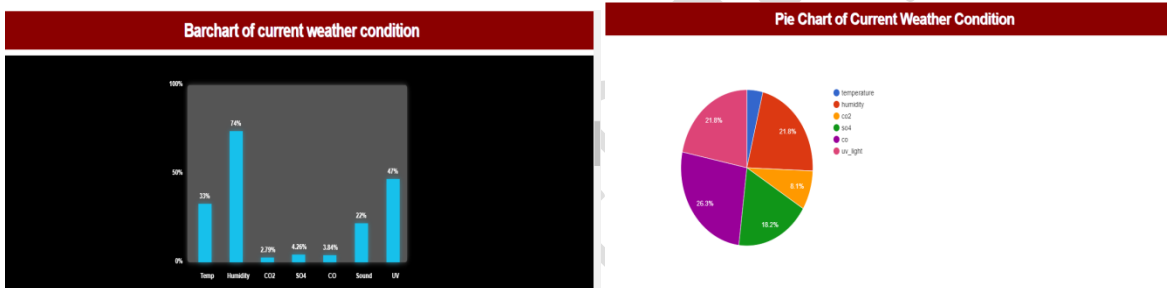


Figure 4.6: Bar chart and Pie chart daily results

Discussion

Quite a few weather stations just detect air pressure and show the results on an LCD screen. Data can be sent as SMS messages to mobile phones or stored in the BLYNK program, but not both at the same time. Users with registered phone numbers can get an SMS message from this project. Graph, bar chart, and pie chart can be used on the webpage design to obtain sensor readings remotely. The embedded map on the webpage allows users to perform location-based searches.

Conclusion

When the data obtained at the generator point is compared to the data collected in offices and the community, the observed data differs from the WHO norm. It demonstrates that when environmental toxins are affected by weather, their spread pace is slowed down. A visual representation of the outcome can be found in table 4.1 on page 52. Real-time data and graphical analysis of the sensed data are available on the cloud. According to the results of this experiment, implanting the device in humans can help save lives. Users can obtain the measured data from a developed system in a specific location using internet-connected devices such as cellphones, computers, and so on. A message can be sent to the registered user's mobile phone number, as shown in Figure 4.3.

5.2 Recommendations

Thus, if the gadget is installed in a school or community, it will aid in the monitoring of weather parameters such as temperature and humidity, as well as air pollutants, by informing folks about weather conditions. Data can also be saved for later analysis. If humans make effective use of the data offered by the system, this project design can help improve the environment. This revealed that there is still a significant amount of opportunity for future expansion, such as the need for additional weather sensors to detect changes in the environment, sensors such as rain sensors, and so on, as well as the installation of a solar system into the project to run for 24 hours.

REFERENCES

- Firdhous, M., & Sudantha, B. (2020). Powered smart weather station for microclimate monitoring. *Indonesian Journal of Electrical Engineering and Computer Science*, 17(1), 508~515. <http://ijeecs.iaescore.com>
- Karthigaeni, K., & Nithyalakshmi, R. (2020). Internet of things based wireless weather monitoring System Using blynk server. *International Research Journal of modernization in Engineering Technology and Science*, 2(9), 2582-5208. www.irjmets.com
- Kashyap, P., Preetham, M., Nayak, R., Uday, B., & Radhika, T. (2020). Intelligent weather prediction techniques using machine learning. *International Research Journal of modernization in Engineering Technology and Science*, 2(7), 2582-5208. www.irjmets.com
- Nivedan, V., & Kannusamy, R. (2019). Weather monitoring system using iot with Arduino Ethernet Shield. *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, 7(1), 2321-9653.
- Prasanna, M., Iyapparaja, M., Vinothkumar, M., Ramamurthy, B., & Manivannan, S. (2019). An intelligent weather monitoring system using the internet of things. *International Journal of Recent Technology and Engineering (IJRTE)*, 8(4), 2277-3878. www.ijrte.com