Arduino Based IoT Mini Weather Station

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***Abstract*— The Arduino Based IoT Mini Weather Station is a cost-effective and versatile project that allows users to monitor weather conditions in real-time. The project uses an Arduino Uno microcontroller and multiple sensors, including the DHT11, MQ-3, BMP180, and BH1750, to measure temperature, humidity, alcohol gas concentration, atmospheric pressure and light intensity. The data collected by the sensors is displayed on an I2C LCD 16x2 display and is sent to a cloud server using the ThingSpeak API via an ESP01 Wi-Fi module. The practical applications of the project include agriculture, outdoor activities, meteorology, and energy efficiency. The project's versatility and cost-effectiveness make it a valuable tool for individuals and organizations interested in monitoring weather conditions in real time. Overall, the project demonstrates the potential of IoT technology and the value of monitoring weather conditions in real-time.**

Keywords— Weather station, Instrumentation system, sensor module, IoT technology.

I. INTRODUCTION

The Arduino-Based IoT Mini Weather Station is introduced with a focus on how the system uses an Arduino microcontroller, a number of sensors, and a Wi-Fi module to gather weather data and send it to the internet. The Arduino processes the sensor data, and the information can either be transferred to a computer for additional analysis or displayed on an LCD screen. The results of this study are prototype weather conditions in a room based on weather data obtained from ThingSpeak [1]. Low-cost weather stations would make it more common in businesses, households, and educational institutions, producing data that may be used based on individual requirements. This information could be shared online through web pages or kept in a database. The history of this data collected over the years would enable the study of climate norms in a particular location, linking it to particular occurrences and helping sectors like agriculture, even enabling forecasting of future climatic manifestations [2].

In this study, we used a variety of technologies to create a straightforward weather station. With this system, users can access weather information from anywhere using an internet connection [3]. The system collects data using various sensors and transmits the data using an Arduino Uno microcontroller. These gadgets can be used to measure the weather conditions in rural or developed places and show them to the public. There are no longer any such portable tools for the same. The suggested system aims to develop Internet of Things (IoT) technology that will monitor temperature, humidity and barometric pressure in the vicinity of where the weather station is installed. Different sensors put on the weather station detect all of this data, and when it is detected, the data is posted to a website [4]. Data from commercial weather stations and the testing results were in agreement. So, one affordable and dependable option for keeping track of weather conditions in a variety of settings is the Arduino-Based IoT Mini Weather Station. It is perfect for a range of applications including indoor and outdoor environmental monitoring, agriculture, and meteorology and is simple to use, small, and portable. An accurate and dependable source of meteorological data is provided by the system, which collects data using a number of sensors and employs an Arduino Uno microcontroller to interpret and broadcast the data.

A popular microcontroller board based on the ATmega328P is called the Arduino Uno. It has a 16 MHz quartz crystal, 6 analogue inputs, 14 digital input/output pins, a USB port, a power jack, an ICSP header, and a reset button. The system utilizes various sensors to collect data and the Arduino Uno microcontroller to process and transmit the data. The system consists of several sensors such as a temperature sensor, a humidity sensor, an alcohol gas sensor, a pressure sensor, and a light sensor [5].

II. PREVIOUS STUDY

In [6], the authors built a weather station that could provide daily, weekly, or monthly forecasts. For the purpose of tracking the varying daytime weather conditions, a smart weather station was constructed in their work. Before giving users an anticipated weather report, an Arduino-based CPU processed the data from the air station's temperature, humidity, pressure, and rain sensors. The results of the investigation were contrasted with those of meteorology, and it was found that they were remarkably similar.

The temperature and humidity sensors in [7] capture data, which the author has designed wireless connection between an Arduino and RF module nRF24L01 to exchange in order to monitor the data shown. The suggested monitoring system uses an Arduino Uno, DHT11 sensor, and RF module nRF24L01 to wirelessly communicate temperature and humidity data. Finally, using an interface between an Arduino Uno and a nRF24L01 module, the actual temperature and humidity will be shown on a 16*2 LCD. This method enables the use of wireless communication at a lower cost and with less power consumption. An environmental monitoring system's implementation details and experimentation findings are provided by the author.

In [8], the author described how he used an Arduino Uno R3 and a DHT11 sensor to create an independent room temperature control system. It was also advised to install a fan speed control system. In this case, the user could adjust the reference temperature range's minimum and maximum values using the keypad. The DHT11 sensor determined the room's temperature and reported the reading in degrees Celsius. The LCD showed both the reference value and the measured value. The sensor's measured value was obtained, and the system's processing component, the Arduino microcontroller, compared it to the established threshold.

The author of [9] built a cutting-edge weather monitoring system and real-time alarm system using the Internet of Things. When compared to 88.678% and 11.322% created by a raspberry pi, the project built on the Arduino Uno was tested and determined to be 95.865% accurate and 4.145% of loss, respectively. In that paper, various models were offered to show an intelligent technique to monitor the environment and an effective, low-cost embedded system.

In [10], author discussed how the work offered thorough insight into the fabrication method and performance analysis of Pd-doped SnO_2 sensors. The research resulted in that publication may open the door to the creation of better alcohol detection sensors for use in a variety of applications.

In [11], the model was tested using real-time sensory data using a range of sensors, including the BMP180, DHT22, and PM2.5 sensor. The author used data from the IQAir website for a single area to train the model. The system's overall effectiveness, which was determined to be 85.27%, points to a promising future for it in real-world applications. Overall, the research offered a unique method for forecasting air quality and monitoring the weather, highlighting the possibility of fusing machine learning methods with sensor-based systems to deliver real-time environmental data.

The author of [12] examined how the LCD's optical characteristics change and proposes a system for intelligently controlling light intensity to adjust the brightness of automotive sun visors in accordance with ambient light levels. The system employed a BH1750 sensor to collect environmental light data, which is processed before being transmitted as an analogue signal to a single-chip CPU for computation and analysis. In order to help drivers, adjust to the brightness of the outside light and drive safely, the technology regulated both the driving voltage and the LCD screen's brightness.

In [13], the author outlined a state-of-the-art system designed to track energy use and gauge power consumption using a hall current sensor. The system made advantage of a wireless network to deliver data to a central server for storage. The system was made up of an Arduino Uno and ESP 8266 interface that communicated sensor data to an Arduino Yun that was pre-programmed to send users alerts often.

The author of [14] described an Internet of Things (IoT)-based semi-real-time system for monitoring clean water quality. The device monitored water turbidity and detected metal levels using an electrode and a turbidity sensor, respectively. The data was delivered in real-time to the Thingspeak web service, with a 12.5 second latency on average. A Wi-Fi hotspot network could be connected to by the system at a maximum distance of 22 metres using the ESP 8266-01 Wi-Fi module.

In [15], the author described a project that aimed to create a working prototype for a device that could measure the carbon dioxide content of indoor air. The system was made up of the MH-Z19 NDIR infrared gas module, the AM2302 temperature and humidity module, and the Arduino Uno microcontroller board. The LCD1602 module, which was linked to an I2C daughter board, was also included. The sensor control application was written and assembled using the IDE software shell. Every five minutes, the device refreshed its LCD panel with information from the sensors, including the temperature, humidity, and inside CO_2 level.

III. COMPONENT DESCRIPTION

A. DHT11

The DHT11 sensor is an inexpensive digital temperature and humidity sensor. Commonly used in hobby electronics projects and educational settings. The DHT11 measures both temperature and humidity and provides the data in a digital format that can be easily read and processed by microcontrollers such as Arduino. The DHT11 uses a capacitive humidity sensor and a thermistor to measure relative humidity and temperature [8]. The data is then sent to the microcontroller via a single wire digital interface. The DHT11 has a relative humidity range of 20 to 80% and a temperature range of 0 to 50°C, making it suitable for a wide range of indoor applications. The DHT11 sensor is widely used in various projects such as weather stations, home automation systems and HVAC systems [9]. They are known for their low cost, small form factor and ease of use.

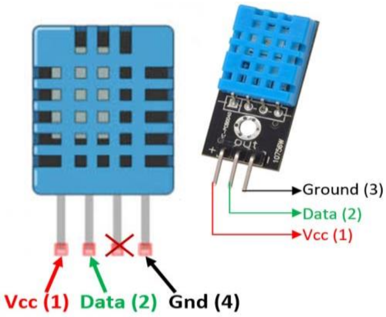


Figure 1: DHT11 Sensor

However, it should be noted that the DHT11 is not the most accurate sensor on the market and readings can be affected by factors such as temperature drift and EMI. Nonetheless, the DHT11 is still a popular choice for many hobbies electronic projects because it is inexpensive and convenient.

B. MQ3

The MQ-3 gas sensor is a low-cost, highly sensitive device used for detecting the presence of alcohol, benzene, and other volatile organic compounds (VOCs) in the air .The MQ-3 gas sensor works by using a metal oxide (SnO_2) sensing material that changes resistance in the presence of VOCs . The change in resistance is proportional to the concentration of VOCs in the air, and this information can be used to detect and quantify the presence of different gases.

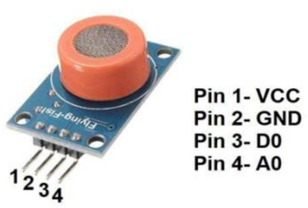


Figure 2: MQ-3 Sensor

The MQ-3 gas sensor provides a simple analog output that can be read by a microcontroller such as the Arduino, which can then be used to trigger an alarm or control other devices based on the gas concentration readings. MQ-3 gas sensors are known for their low cost, high sensitivity, and fast response time, making them popular in hobby electronics projects and educational institutions [10].

C. BMP180

The BMP180 is a digital barometric pressure sensor, which is based on piezo-resistive technology. The air pressure sensor varies with the weather and altitude (Altitude) and measures the absolute pressure surrounding the sensor [16]. It can measure both barometric pressure and temperature with high accuracy. It is based on MEMS technology (Micro-Electro-Mechanical Systems) and is manufactured by Bosch Sensortec.

The accuracy of the BMP180's measurements of temperature and barometric pressure, which range from -40 to 85 °C and 300 to 1100 hPa, respectively, is 1.0 °C and 0.02 hPa, respectively. The BMP180 sensor can be used in a wide range of applications, such as weather forecasting, altitude measurement, and industrial control [11].

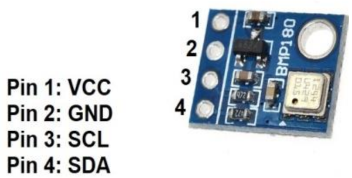


Figure 3: BMP180 Sensor

D. BH1750

A digital light sensor called the BH1750 is used to gauge ambient light levels. It provides a high-resolution measurement of the intensity of the ambient light and is based on a photodiode and an integrated circuit [12]. The sensor has a resolution of 1 lux and can measure light intensity in the range of 1-65535 lux. It makes use of the I2C communication protocol, enabling the connection of numerous BH1750 sensors to a single microcontroller using just two communication lines.

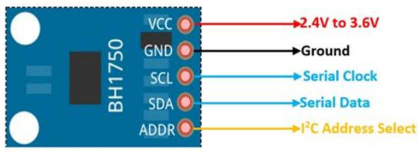


Figure 4: BH1750 Sensor

The BH1750 sensor can be used in a wide range of applications, such as lighting control, automatic light dimming, and ambient light sensing.

E. ESP01 8266 Wi-Fi Module

A low-cost, low-power microcontroller with integrated Wi-Fi capabilities is called the ESP8266. It is built around the Expressif Systems-produced ESP8266 chip [13]. A 32-bit microcontroller with built-in Wi-Fi is provided by the chip, enabling connections to wireless networks and the internet. The ESP-01 module can be programmed using the Arduino IDE, which allows for easy integration with a wide range of sensors and actuators.

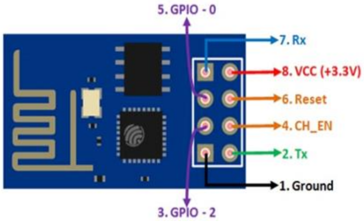


Figure 5: ESP01 8266 Wi-Fi Module

The ESP8266 has a wide range of features, including support for a variety of wireless protocols, such as TCP/IP, HTTP, and MQTT, which allows it to connect to a wide range of cloud services, such as Thing Speak, Adafruit IO, and Google Cloud IOT. The module also supports OTA (over-the-air) updates, which allows for easy updates to the firmware without the need for a physical connection [14].

F. I2C LCD 16X2

A liquid crystal display (LCD) that interfaces with a microcontroller using the I2C communication protocol is called an I2C LCD 16x2.The display is typically composed of a 16x2 matrix of characters, which allows it to display up to 32 characters at a time.

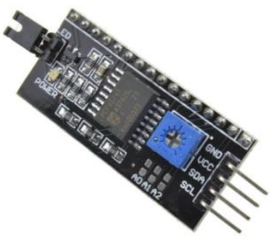


Figure 6: I2C LCD 16x2

The I2C LCD 16x2 uses the I2C communication protocol, which is a two-wire interface that uses a clock (SCL) and data (SDA) line to communicate with a microcontroller. This allows multiple I2C devices to be connected to a single microcontroller using only two communication lines [15].

The I2C LCD 16*2 is widely used in a variety of projects, such as home automation, weather stations, and other DIY projects. It is also used in embedded systems, such as industrial control system and medical devices.
The display is easy to interface with a wide range of microcontroller, such as Arduino, Raspberry pi, and PIC microcontroller.

IV. SYSTEM IMPLEMENTATION

A. Implementation

The implementation of the Arduino Based IoT Mini Weather Station involves the following steps: -

Setting up the hardware components: The first step is to gather all the necessary components such as Arduino Uno, sensors (DHT11, BMP180, MQ-3, and BH1750), LCD display, and ESP01 Wi-Fi module, PCB, and I2C protocol and connect them as per the circuit diagram.

Writing the code: The next step is to write the code for the Arduino Uno board using the Arduino IDE software. The code consists of setting up the sensors, taking readings from them, displaying the readings on the LCD display, and sending the readings to the ESP01 Wi-Fi module. Now, the Arduino IDE software is used again to write the code for the ESP01 Wi-Fi module to receive the incoming readings from the microcontroller board and upload them to the ThingSpeak cloud server.

Uploading the code to the Arduino Uno board: Once the code is written, it is uploaded to the Arduino Uno board using the USB cable connected to a computer.

Uploading the code to the ESP01 Wi-Fi module: Once the code is written, the wi-fi module is connected to the Arduino board in a specific circuit to upload the code.

Connecting to ThingSpeak cloud platform: The ESP01 Wi-Fi module is used to connect the weather station to the ThingSpeak cloud platform. This involves configuring the Wi-Fi module to connect to the internet and sending data to the cloud platform.

Displaying the data: The weather data collected by the sensors is displayed on the LCD display in real-time, while the data sent to ThingSpeak can be accessed via a smart phone or computer using an internet connection.

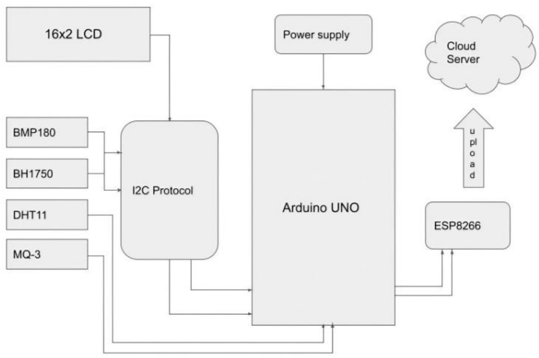


Figure 7: Schematic Diagram of Arduino Based IoT Mini Weather station.

Once implemented, the weather station can provide a wealth of information about the local weather conditions, which can be useful for a variety of applications, including agriculture, construction, and transportation.

B. Connections

The mini weather station based on Arduino Uno consists of various components that work together to collect and display weather data. The system is implemented as follows: -

Arduino Uno Board: The Arduino Uno board is the main microcontroller that is used in the weather station. It is the brain of the system that receives, processes, and transmits data from the sensors to the cloud server. The board is connected to a USB cable for power.

DHT11 Temperature and Humidity Sensor: The DHT11 sensor is connected to digital pin 7 of the Arduino board. It measures the temperature (℃) and humidity (%) of the surrounding environment.

MQ-3 Alcohol Gas Sensor: The MQ-3 sensor is connected to analog pin A0 of the Arduino board. It detects the presence of alcohol gas in the air (ppm).

BMP180 Pressure Sensor: The BMP180 sensor is used to measure the atmospheric pressure. It is connected to the I2C pins of the I2C protocol board, which are pins A4(data address pin) and A5(clock pin).

BH1750 Light Sensor: The BH1750 sensor is used to measure the light intensity of the environment. It is also connected to the I2C pins of the I2C protocol board.

I2C LCD Display: The 16x2 LCD display is used to display the weather data collected by the sensors. It is connected to the I2C pins of the Arduino board.

ESP01 Wife Module: The ESP01 module is connected to pins 10 and 11 of the Arduino board, which are used as RX and TX pins respectively. It uses 3.3V power supply pin. It is used to connect the weather station to the internet and send data to the ThingSpeak API cloud server.

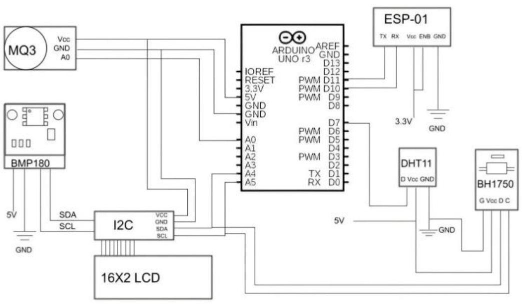


Figure 8: Circuit Diagram

The system works by collecting weather data from the sensors and processing it using the Arduino board. The data is then displayed on the LCD display and sent to the cloud server via the Wi-Fi module. The data is then displayed on a graph on a smartphone app or on the ThingSpeak website. The system operates continuously and collects data every 10 seconds and each graph on the cloud server is updated in 1 minute.

V. SIMULATION RESULTS

A. Testing

The mini weather station was tested by observing its readings on the Arduino IDE serial monitor. The readings obtained from the weather station were then compared to the readings obtained from a commercial forecasting system. This was done to evaluate the accuracy of the mini weather station and to determine its reliability for weather forecasting purposes. By comparing the readings of the mini weather station with those of the commercial system, it was possible to identify any discrepancies and calibrate the mini weather station if necessary. The results of the comparison were used to determine the precision of the mini weather station and its suitability for different applications.

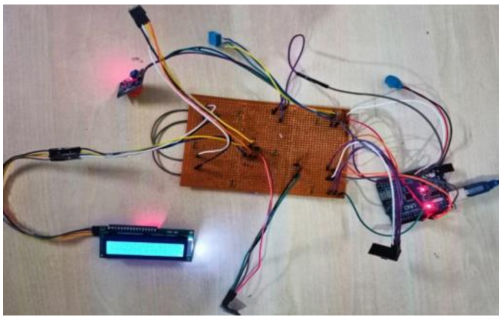
Table 1: Test samples in Arduino IDE

S. No.	Humidity (%)	Temp (°C)	Alc. Gas Conc. (PPM)	Pressure (Pa)	Light Intensity (Lux)
1.	34.00	23	343.00	97222	40.83
2.	35.00	23	326.00	97219	1144.17
3.	40.00	23	329.00	97227	128.33
4.	35.00	23	323.00	97230	887.50

B. Results

The mini weather station built using Arduino Uno provides real-time data for various environmental factors such as humidity, barometric pressure, temperature and light intensity. The collected data is displayed on a 16x2 LCD display in a readable format for the user. Additionally, the data is also uploaded to ThingSpeak cloud for remote access and analysis.

The data displayed on the LCD screen is in a simple format that is easily understandable by the user. The temperature reading is displayed in degrees Celsius, humidity reading is displayed in percentage, pressure reading is displayed in Pa, and light intensity reading is displayed in Lux.



(a)

(b)

Figure 10: snapshots of the hardware model

The inclusion of a snapshot of the hardware model of the 'Arduino Based IoT Mini Weather Station' in a research paper offers a visual depiction of the parts and connections of the system.

The data uploaded to ThingSpeak cloud provides a graphical representation of the collected data. Using the internet, the user can access the data remotely from any location. The data can be analysed to obtain insights and trends in environmental factors.

LCD Parameters

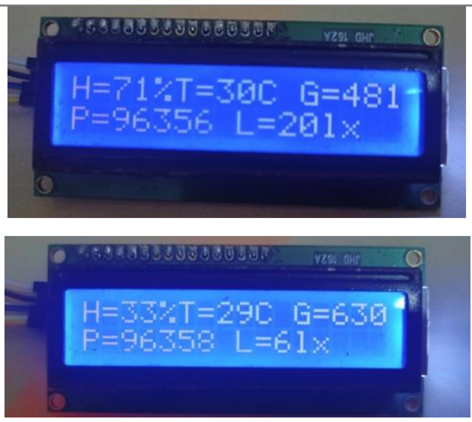


Figure 11: Results on LCD

Additionally, ThingSpeak provides APIs for integrating with other applications, enabling the user to develop custom applications for data analysis and visualization.

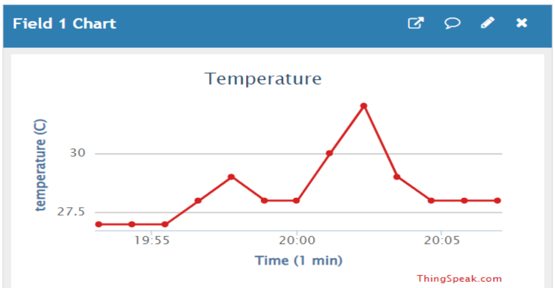


Figure 12: Temperature on Thingspeak

Figure 12 and 13 shows the graphical representation of the temperature and humidity data collected from the mini weather station.

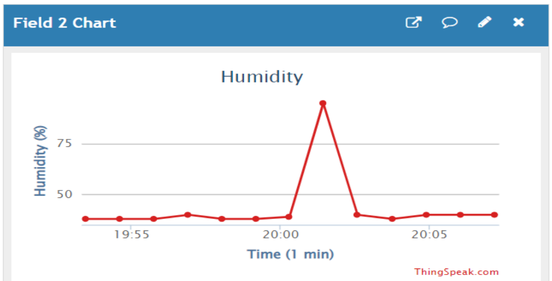


Figure 13: Humidity on ThingSpeak

Figure 14 and 15 shows the graphical representation of alcohol concentration and atmospheric pressure data collected by the mini weather station. The graph shown in Figure 14 shows the concentration levels over time and can be used to track the amount of alcohol in the air. The atmospheric pressure data in Fig 15 is displayed in real-time and accessible from any location with an internet connection.

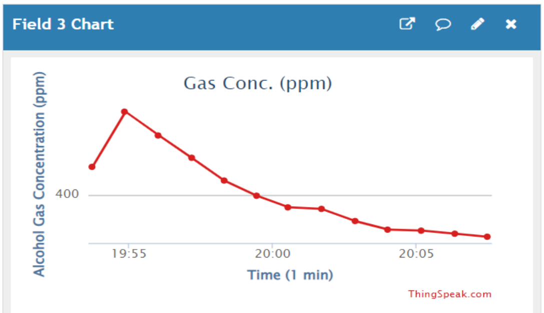


Figure 14: Alcohol gas concentration graph on ThingSpeak

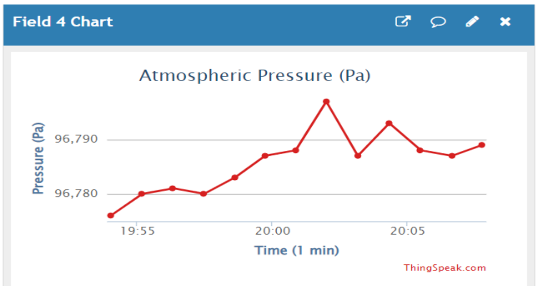


Figure 15: Atmospheric pressure graph on ThingSpeak

One of the benefits of using ThingSpeak as the cloud server for the Mini Weather Station is that users can easily download the data collected by the station. ThingSpeak provides an option to download the data in a spreadsheet format, which can be useful for further analysis and visualization.

VI. CONCLUSION

The Arduino Based IoT Mini Weather Station project is an outstanding example of how IoT technology has the potential to let people and businesses monitor the weather in real-time. The project offers useful insights about environmental conditions that may be applied across a wide range of applications, and it is affordable, adaptable, and uncomplicated to build.

Using a variety of sensors, including the DHT11, MQ-3, BMP180, and BH1750, which detect temperature, humidity, alcohol gas concentration, atmospheric pressure, and light intensity, the project's main goal is to give consumers access to real-time weather data. The gathered data is then shown on a 16x2 I2C LCD display and uploaded to a cloud server using an ESP01 Wi-Fi module and the ThingSpeak API. By contrasting the values produced by the sensors in a controlled setting with a commercial forecasting system, the accuracy of the sensors was evaluated.

An effective instrument for gathering and interpreting weather-related data is the Arduino Based IoT Mini Weather Station. The data gathered can be used for a multitude of purposes, and it is an economical and effective approach to monitor weather conditions in various situations. The weather station can precisely record information on temperature, humidity, pressure, light intensity, and air alcohol content by employing a variety of sensors.

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