Design and Implementation of IoT Based Local Weather Station – An Experimental Setup

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***Abstract*— In contemporary times it is observed that the climatic and weather conditions have become skeptical and unpredictable. To confound this unreliable nature and variability of weather conditions, we present an experimental setup of IoT-based local weather stations. This paper presents the design and implementation details of the experimental setup. ESP8266-based Wi-fi module NodeMCU (12E) is the brain of the prototype. Two sensors are connected to the NodeMCU, namely a temperature and humidity sensor (DHT11), and an Air quality gas sensor (MQ135). Additionally, to display the results, we present 'VIT Weather Station' - A local weather station app which can keep people updated regarding the environmental conditions utilizing live data collection and display. The device will monitor the temperature, humidity, and air quality index. This application is supported on Android as well as IOS systems. Local users can also view the monitored data from Twitter for easier convenience.**

Keywords—Internet of Things, Weather monitoring, Weather Station App, Twitter updates.

I. Introduction

With the emergence of high-speed Internet, more and more humans around the globe are interlinked. The Internet of Things (IoT) additionally connects not only humans but also electronic devices [1]. The wifi-enable system adds fuel to this system. This system measures the atmospheric pressure, temperature, and humidity, and the obtained results are demonstrated on an LCD screen [2]. The rudimentary idea behind the Internet of Things (IoT) is to concatenate different electronic devices over a network, recover data from these devices (sensors), which can be disseminated in any way, and upload it to any cloud service to be analyzed and processed. This data can be notified to others via a variety of channels, like SMS, Twitter, etc. [3].

Weather monitoring plays a crucial role in determining the present climate, detecting climate change, and enabling automated analysis of data fetched to envision future climate changes. This system has applications in numerous fields. Our project is an example of the same. The experimental setup that we have created will monitor the weather conditions in our institute to facilitate the proper settings of central facilities, such as lighting and air conditioning, depending upon the weather characteristics of the day, thus enabling live reporting of weather.

Earlier, individuals dwelling in their work zone had no clue about the environmental parameters outside their windows. It is difficult for an individual to analyze these climatic conditions. This device can become quite handy in such situations. In addition to these problems, one of the most significant scourges in today's times is air pollution, on account not only of its horrifying consequences but also, its impact on health due to augmenting mortality and morbidity. We have tried to solve these problems by combining these sensors with a data acquisition system, which has proved to be a more promising practice for temperature and humidity monitoring [4].

II. Working Principle

A. Hardware

Firstly, we need to power the circuit and wait for 5 minutes before sending or receiving any data as the sensor needs to warm up. The microcontroller - Node MCU, reads the data from DHT22 and the MQ135 sensor, which will monitor the temperature, humidity, and air quality index of the surrounding area. The systems at both weather stations function synchronously to monitor and record the data at their respective stations. The program decodes the data obtained by the sensors and stores it in the code variables. These variables are recorded in firebase. The hardware components that have been utilized for the setting of the experiment are Node MCU, MQ135 sensor, Boost converter, TP4056 Module, 3500maH Li-po Battery, DHT22 module, SPST Switch, and OLED Display. Fig. 1. depicts the pictorial circuit diagram of the experimental setup used. Fig. 2. shows the block representation of the same. All the hardware components are represented in these diagrams, which enables a better understanding of the positioning of components.

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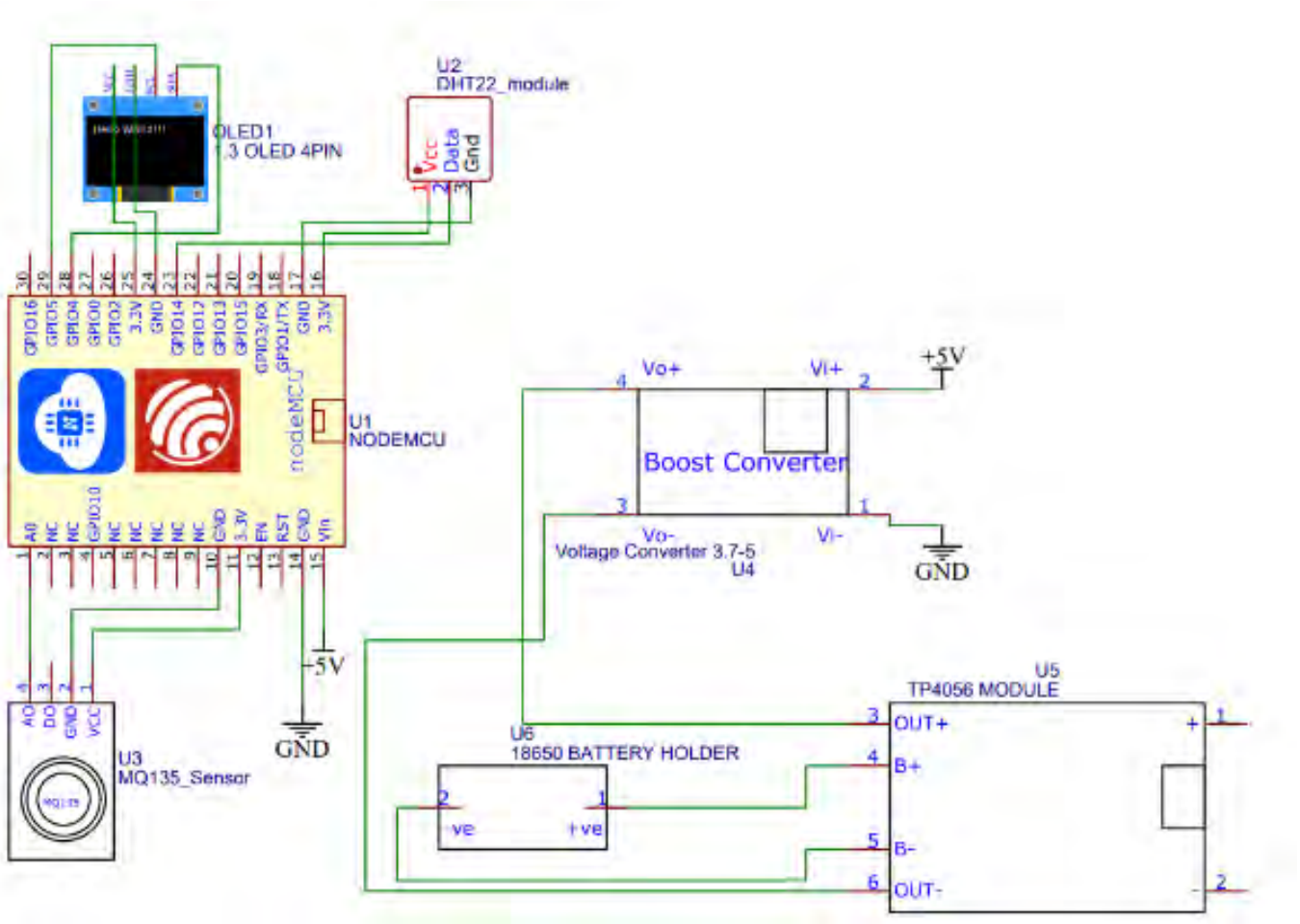

Fig. 1. Pictorial Circuit Diagram

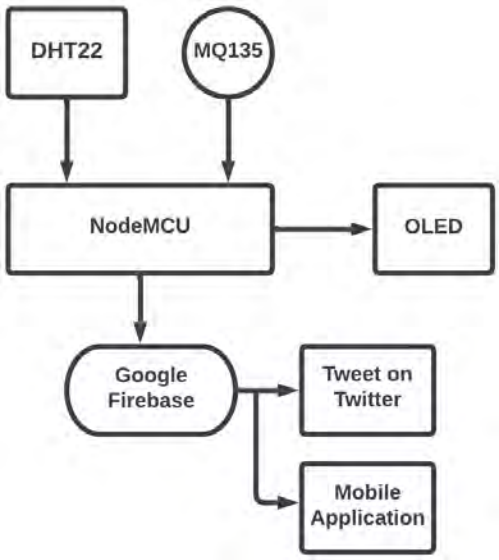

Fig. 2. Block Diagram

B. *Mobile Application*

The data obtained from the firebase database gets displayed on the application. The android application is developed on Android Studio using Flutter. Flutter is a cross-platform framework that is highly recognized for developing a high-performance mobile application. Google released Flutter in 2016 [5].

As shown in Fig. 3, the application named 'VIT Weather Station' displays the temperature, humidity, and air quality index of both the local weather stations using a color-coded gauge.

Fig. 3. VIT Weather Station Application

C. *Twitter Application*

Fig. 4. shows that the estimated data of the current climatic parameters is also notified to its users on Twitter on an hourly basis using Firebase Cloud Functions.

Fig. 4. Twitter Application

III. Apparatus for Setup

TABLE I. APPARATUS USED IN THE PROJECT

Sr.No	Name	Properties
1	OLED Display	a. Lower power consumption b. Simpler design c. Durable d. Can operate in a broader temperature range
2	DHT22 -Digital Temperature & Humidity Module	a. 4-pin device b. Senses the surrounding temperature and humidity
3	MQ135- Air Quality Gas Sensor Module	a. Identifies harmful gases and smoke, which includes ammonia (NH3), sulphur (S), benzene (C6H6), and CO2. b. Pin for both digital and analog output
4	DC-DC Micro Boost 5V USB	a. 0.9-5V input, output 5V b. Useful for onboard USB device supply solutions
5	TP4056-C-Type USB Protection Module	a. C Type USB Type b. 5V 1A 18650 Lithium Battery
6	Nodemcu ESP8266 Wifi ESP-12E	a. Microcontroller: 32-bit RISC CPU Xtensa LX106 b. Operating Voltage: 3.3V c. Input Voltage: 7-12V
7	SPST Switch	a. Two terminals b. Controls a single circuit
8	3500maH Li-po Battery	a. Capacity of 3500mAH b. Thin, light, and powerful

IV. Applications

Local weather stations have a wide range of applications in many real-world scenarios. For professional use, these devices are used for collecting data and proffering pertinent reports to the user about the climatic parameters. It imparts real-time data, allowing the user to stay voguish on current weather. The weather station application makes it more leisurely and more coherent to use. It paves the way towards the foundation of an automated home or under our condition, a smart institution, that we aim to create. Additionally, it has its application in households and offices, where a local weather station can be incorporated. This device can also be used to detect weather conditions in flood lines, reservoirs, hydroelectricity, water treatment, and urban drainage, and updates of these can be provided on the Twitter app as well for weather monitoring by local users.

V. Observations

A. *Output displayed on the hardware device:*

The weather data which includes Temperature, Humidity, and Air quality index is displayed on the OLED display. In Fig. 5, the overall representation of the experimental setup can be seen. All components are connected according to the pictorial circuit diagram explained in Fig. 1. We have made two identical setups, to primarily make the measurements more accurate, a secondarily, we have used an algorithm in our code that measures the average of these two systems and then displays it as the final measured outcome of the weather station.

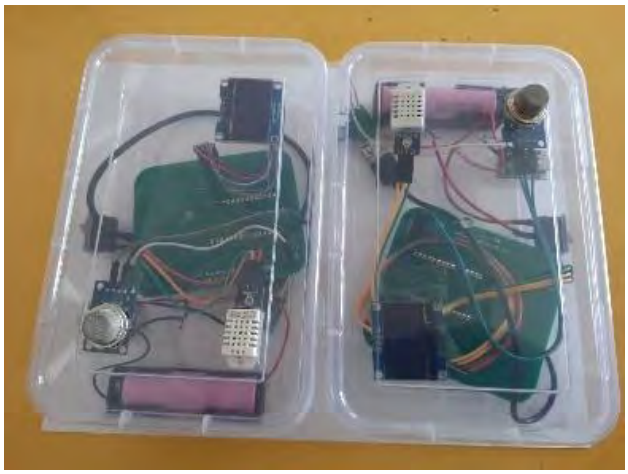

Fig. 5. Final Setup

B. *Output displayed on the weather application and Twitter application:*

'VIT Weather Station' is the weather application that we have developed which is available in android as well as IOS devices. The weather application displays the various factors measured by our experimental setup and also shows a comparison between the two weather stations. In Fig. 6, and Fig. 7 you can see, there are three gauges for temperature, humidity and air quality index respectively. In each of these entities, there are two local stations designed and built to give accurate readings of the weather. On the top left corner of the homepage of the app, are 3 parallel lines situated. These lines open a side popup which also has the three entities along with 2 more options of 'About page and View on Twitter page'. The 'View on Twitter page' option will take you to the Twitter application, displaying the weather parameters and a timely update for its users.

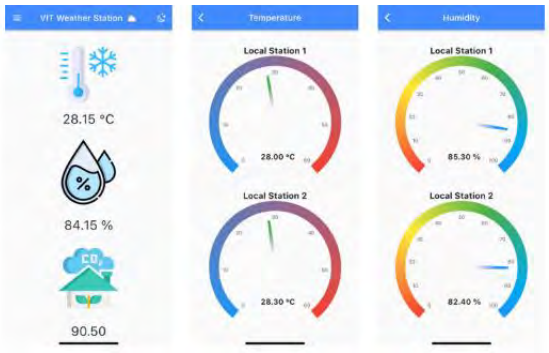

Fig. 6. Weather Application

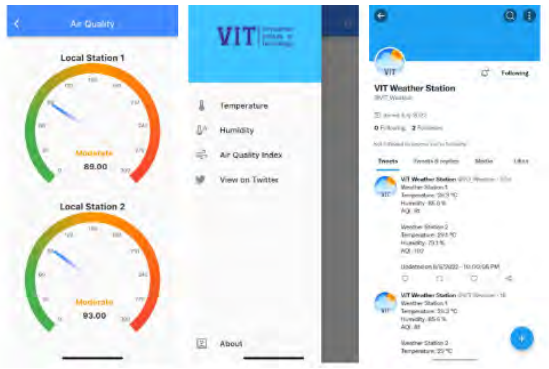

Fig. 7. Twitter Application

VI. RESULTS

After performing an accuracy analysis between the output of the weather app and the search results of google, which is a standardized measured value. For this analysis, we have compared three factors: temperature, humidity and, air quality.

Given below are the results:

A. *Accuracy analysis based on comparing: Temperature*

TABLE II. TEMPERATURE ACCURACY ANALYSIS

No of days	Temperature measured by weather app (in °C)	Temperature by Google (in °C)
1	31	33
2	34	31
3	31	32
4	28	28
5	31	33
6	32	32
7	33	34

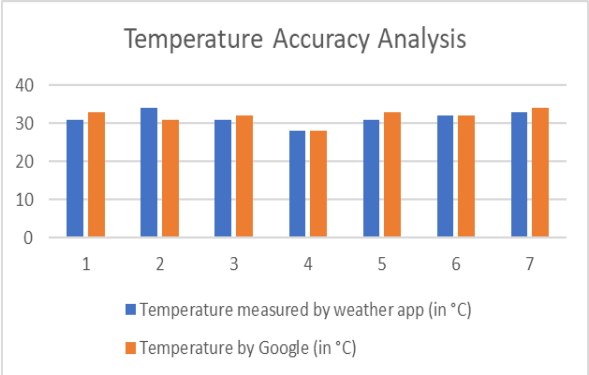

Fig. 8. Temperature Accuracy Analysis

B. *Accuracy analysis based on comparing: Humidity*

TABLE III. HUMIDITY ACCURACY ANALYSIS

No of days	Humidity measured by weather app (in %)	Humidity by Google (in %)
1	50	48
2	57	63
3	60	52
4	59	54
5	45	51
6	58	69
7	68	70

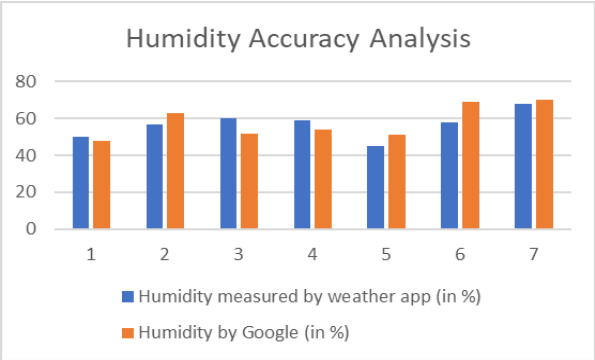

Fig. 9. Humidity Accuracy Analysis

C. *Accuracy analysis based on comparing: Air Quality*

TABLE IV. AIR QUALITY ACCURACY ANALYSIS

No of days	Air quality measured by weather app	Air quality by Google
1	96	83
2	108	95
3	83	92
4	125	113
5	108	96
6	91	101
7	97	88

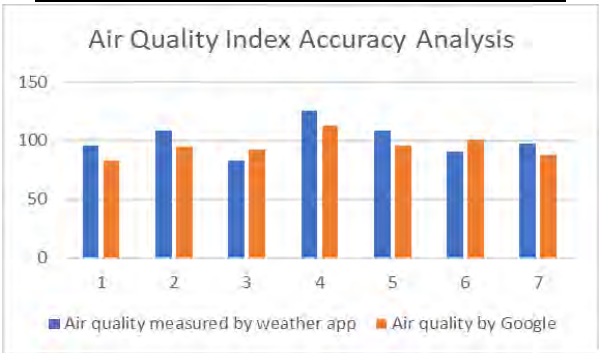

Fig. 10. Air Quality Accuracy Analysis

According to the accuracy analysis, we can understand that there is a discrepancy of ± 10% error margin that we can see. The probable reason for this could be that the components used in the experimental setup are of lower quality and not of the industrial level. These are just for basic prototyping. We can also make another prediction by our experiment, that different sensors provide different outputs that might not be identical to each other but will have an identical pattern that shows the climatic characteristics of the desired area of conduct.

VII. Lessons Learned

- At the onset of this project, our fundamental objective was to dig deep into embedded systems, and the operation of Automation with them. The implementation of IoT not only nurtured our software skills but also cultivated our interest in android development.
- The team indeed faced certain problems, mainly while understanding the features of each hardware component, and then designing an appropriate circuit. The selection of right hardware components was an arduous task.
- While we were stuck, we also required guidance from some of our friends and teachers, who helped us solve our doubts about Flutter coding, and android development.
- One other significant learning from this project was data analysis, which we used for accuracy analysis.
- In order to avoid the basic problems that we faced, we have learned the importance of market survey and skill development (as a prerequisite), which we will surely implement in all our endeavors henceforth.

VIII. Conclusions

This paper illustrates the design and implementation of IoT based weather monitoring experimental setup for our institute that is used for monitoring climatic parameters. The embedded sensor networks have ascertained themselves to be trustworthy solution sensing for our setup. The sensors have been integrated with the system to survey and tally the temperature, humidity, and air quality in a specific area using information and communication technologies [10]. The application and its features like the Twitter update are user-friendly. Our primary aim is to facilitate the proper settings of the central facilities of our institution, depending upon the weather parameters fulfilled. As a future scope of this project, we aim at automating our setup, making it more compact, faster, and industry-specific. Additionally, we can send immediate alert messages or e-mails to the users when the parameter changes are drastic. [11] Thus, the weather station application provides visually appealing and understandable visuals to highlight the weather characteristics aesthetically and concisely.

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