CHAPTER 1: INTRODUCTION

The Internet of Things (IoT) has become one of the most integral parts of modern technology. IoT-enabled system can collect vast amounts of data using low-cost embedded sensors and devices. The industrial scope of the convergence of the Internet of Things (IoT) and Machine Learning (ML) is broad and informative. The Internet of Things generates massive amounts of data from millions of devices. Machine learning refers to teaching machines to make predictions without explicitly programming them. Instead, they are driven by historical data to predict new insight outcomes [1]. Furthermore, ML can be used to make forecasts by analyzing past behavior to identify patterns and offer predictions of future weather. Machine Learning (ML) and Internet of Things (IoT) can work together to make life better.

To develop an IoT system, a thing is required which should be equipped with necessary sensors, actuators and a communication interface. The communication interface is needed to connect the thing to the internet that allows them to send the data to cloud or at remote machine for monitoring and also for analytics purpose. The thing can also receive the control information based on some analytics and take some actuating decision. In the proposed system, the things refer to the NodeMCU that includes firmware, which runs on the ESP8266 Wi-Fi SoC. The cloud refers to the MySQL and Google Sheet for monitoring the data. The analytics refers to the machine learning algorithm i.e. a random forest algorithm mathematical model. This model is trained with the prerecorded data values of temperature and humidity. Further, the web application is used which takes date and time and predicts accordingly.

The project is aimed at developing and testing the use of Machine learning to predict and take a decision in providing the information about future weather conditions for the particular location. The solution will need to be easy to use, simple, secure, and robust. To achieve this testing will need to be carried out to create a useful system [2].

Website Link : https://iotespml.000webhostapp.com/

Web-app Link : https://iotespml.anvil.app/

CHAPTER 2: COMPONENTS

A. HARDWARE USED:

Table 1: *Required Components*

S.No.	Name of Components	Quantity
1	Nodemcu (ESP-12E) module	1
2	DHT22 sensor	1
3	Power Bank	1
4	Jumper wire	3
5	Bread-board	1
6	Power Cable	1

1.) Nodemcu ESP-12E:

NodeMcu is a popular and widely used development board based on the Espressif ESP8266-12E Wi-Fi (802.11 b/g/n) System-On-Chip, loaded with an open-source, Lua-based firmware. It's perfect for IoT applications and other situations where wireless connectivity is required. The chip has a great microcontroller equipped with prototyping board which can be programmed using the Arduino IDE [3].

Table 2: *Nodemcu Specifications*

DETAILS	SPECIFICATIONS
Operating Voltage	3.3V
Digital I/O Pins (DIO)	16
Analog Input Pins(ADC)	6
UARTs	1
SPIs	1
I2C	1
Flash Memory	4 MB
SRAM	64 Kb
Clock speed	80 MHz

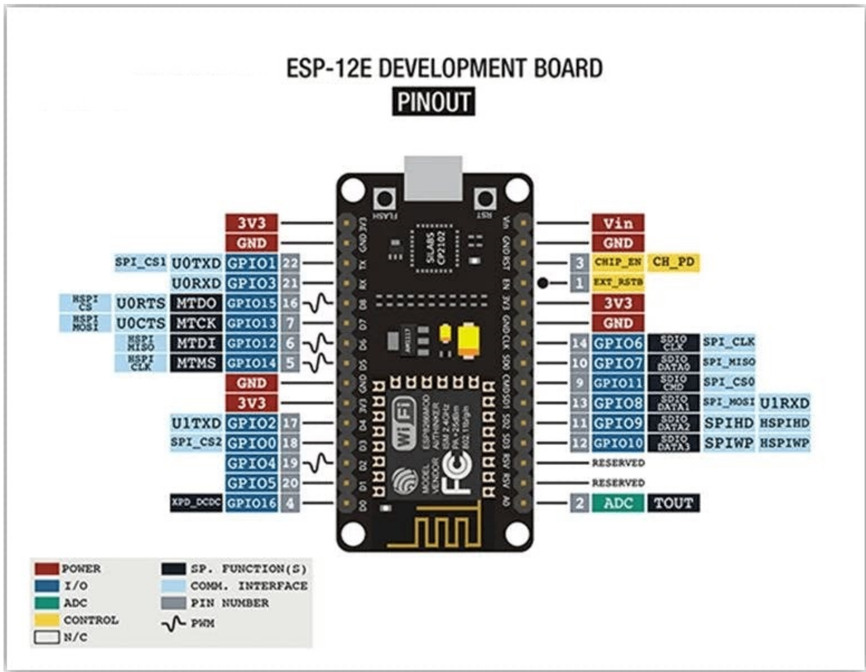

Figure 1. *ESP-12E Development Board Pinout*

2.) DHT22:

The DHT22 is a basic, low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin. No pull-up resistor needed. Just plug right into ESP8266. It is typically a hand wired circuit using a pegboard with press in terminals. Wire wraps or hand soldered wires connect discrete components together. Connecting Wires/Jumpers are used to connect NodeMCU with DHT22 [3].

Table 3: *DHT22 Specifications*

DETAILS	SPECIFICATIONS
Operating Voltage	3 - 5V
Operating Current	2.5 mA
Humidity Range	0 –100% (2-5% accuracy)
Temperature Range	-40 to 80 °C (±0.5°C accuracy)
Sampling rate	0.5 Hz (Once every 2 seconds)
Body Size	27mm x 59mm x 13.5mm (1.05" x 2.32" x 0.53")
Pins	3
Weight	2.4 g

Figure 2. *DHT22 Sensor*

3.) Power Bank:

The capacity of power bank is 3350mAh/12.06Wh Lipstick-Size with Portable Aluminum Design (3.7 × 0.9 × 0.9 in, 3oz). PowerIQ detects the device to deliver its fastest possible deliver charge speed upto 1 amp. It recharges in 3-4 hours with a 1 amp adapter (5V) and the included Micro USB cable [3].

Figure 3. *Power Bank*

B. SOFTWARE USED:

The Arduino IDE (Integrated Development Environment) is the environment, where code is written, compiled and uploaded to the Arduino compatible board such as Nodemcu. A MySQL and Google sheet are used for an Internet of Things platform that lets the user to collect and store sensor data in the cloud. Typically, website also contains multimedia contents (words, pictures and graphs) and code written in PHP, HTML, CSS, and JavaScript to control the look and behavior of that content. Google Colab is a very popular and flexible tool which helps put the machine learning code, output of the code and any kind of visualization or plot etc. in the same document. The anvil platform is used to develop web application to enter the date and time and get the temperature and humidity [3].

CHAPTER 3: OPERATIONS

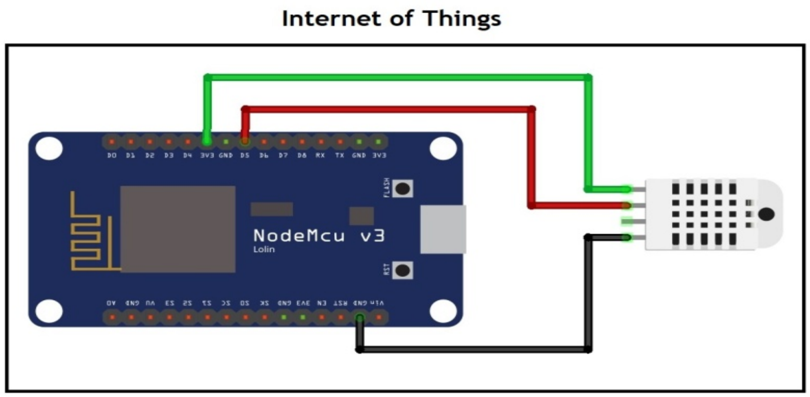

Figure 4. *Schematic Diagram*

After making all the connections as shown in Figure 4 the power supply is provided to the Nodemcu through a USB cable, which is connected with the personal computer. We have written two code modules. The first one is to connect to the sensor in Arduino code and the second code module is for the web page which is written in PHP, HTML, CSS and Javascript. Before uploading code, it needs to verify. So, Open Arduino ide then write code there and click on verify and wait for almost 1-2 min to complete verification and after providing the connection to hardware, choose an option to upload the code then it compiles and done uploading successfully. Open the serial monitor, it shows the connection of system with Wi-Fi. When hardware connection is established, HTTP request starts processing, and then it will show an IP address on the serial monitor. The data logger is showing in the website. Hence, the Figure 5 shows the result on the webpage contains different parameters information from the weather [4].

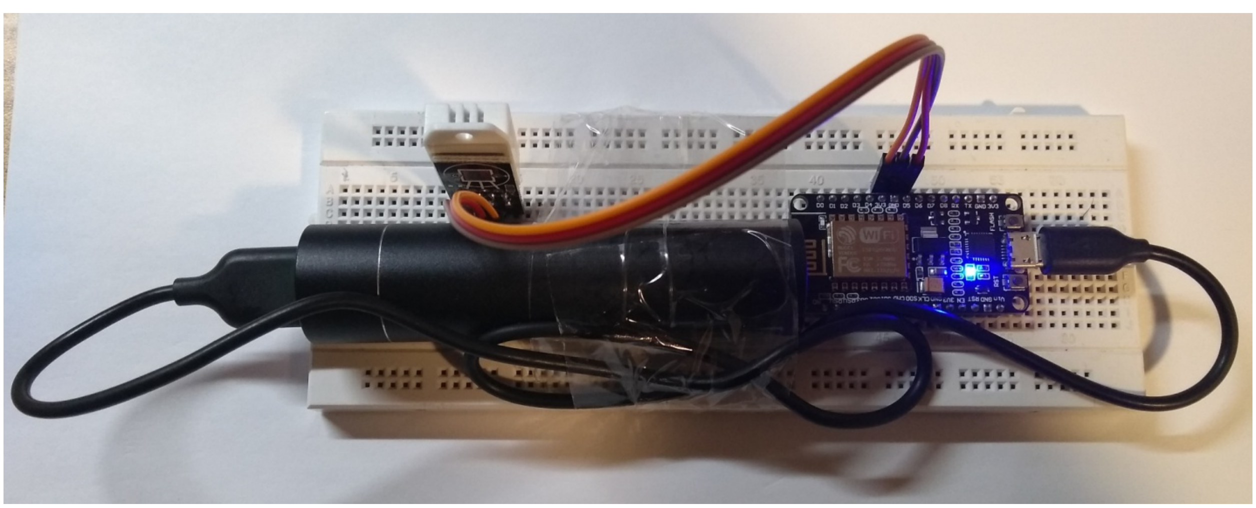

Figure 5. *Circuit Diagram*

CHAPTER 4: DESIGN, SIMULATION AND TESTING

The detailed block diagram to explain the complete process of weather forecasting and prediction done with the help of artificial intelligence:

A. Weather Data Input section

In this section, a combined sensor to measure both temperature and humidity is used. The sensor works well to send the real time data continuously to the interfaced microcontroller. The controller is powered with a voltage supply through a power bank. The function of this section is to collect the readings of the weather data. The DHT22 sensor is connected with NodeMCU, which measure temperature and humidity as shown in Figure 5. It is connected to digital I/O pins. The complete block diagram of the system is demonstrated in Figure 6. The measured values are ready for further processing based on the requirement [5].

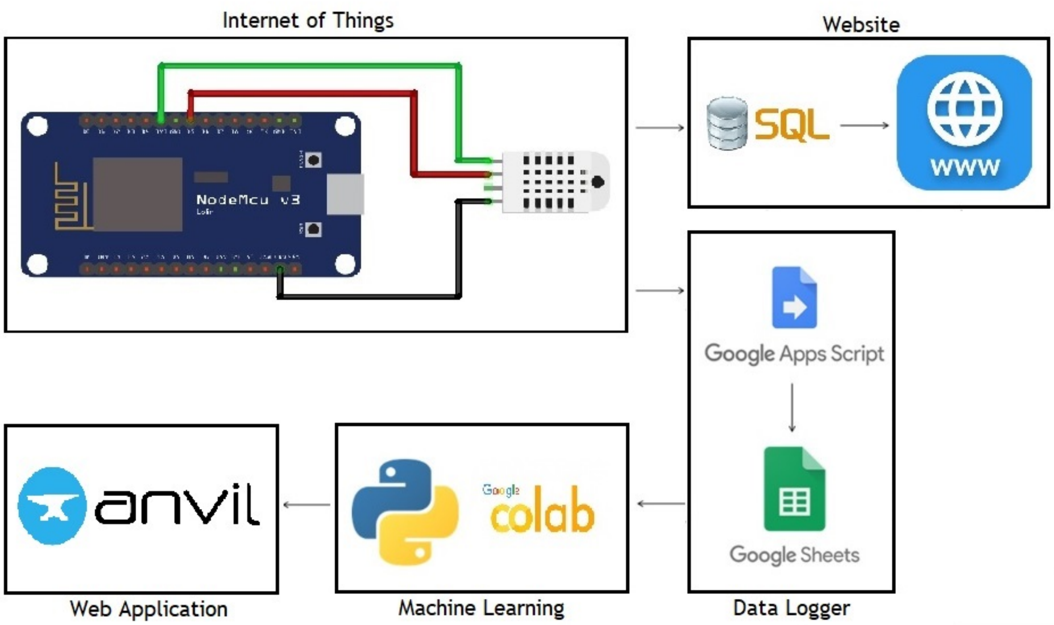

Figure 6. *Block Diagram of the Complete IoT System*

B. Data logger and Display Section

Using NodeMCU module, data is sent to the Google spreadsheet and MySQL cloud server (database) as shown in Figure 4. Further, MySQL data can now be displayed on a Website that reflects measured readings of sensor. At the same time, a Google spreadsheet is also used to record the different values of temperature and humidity in a csv file format as shown in Figure 7 and Figure 8. The final spreadsheet with recorded data will be the dataset file available for the machine learning prediction [6]. The 000webhost powered by Hostinger server is used for Website domain and the anvil web app developer platform is used for web-application as shown in Figure 10.

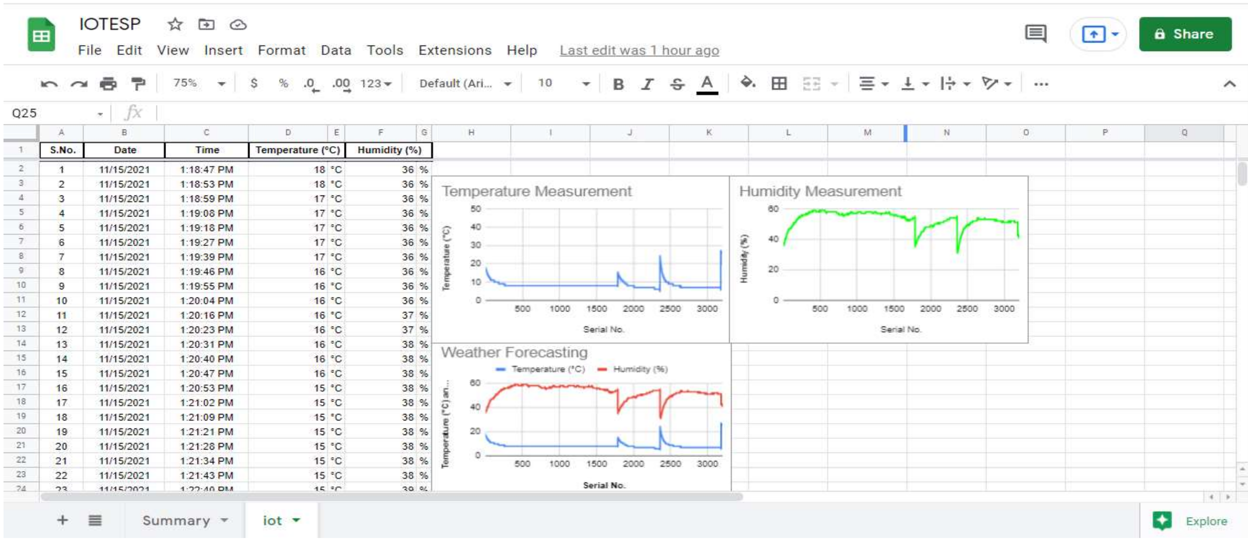

Figure 7. *Data logger Google spreadsheet*

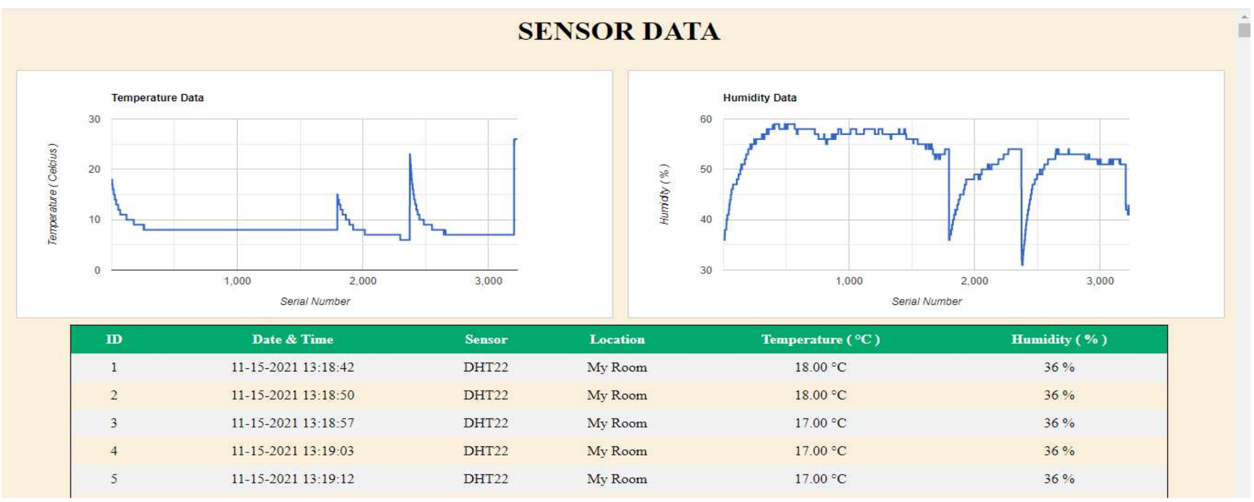

Figure 8. *Website*

C. Weather Prediction Section

This section includes the setup for the dataset being given as input to machine learning models to accurately predict the temperature and humidity. The algorithms will make the prediction based on various approaches and different sets of data. A model based on Random Forest algorithm [8] in Google Colab (Python IDE) is used and trained with the pre-recorded values stored in the Google spreadsheet. Further, NodeMCU records the real time values of temperature and humidity of a particular place or location that are used to test the model and take decision. With the help of the model an attempt to predict the feasibility of a match is made. A LED is used to predict the match result. The accuracy of this model is approx 98% as shown in Figure 9 and Figure 10. The predicted values will be displayed on the web application [8].

```
print('    Date           Time       Temperature    Humidity')
for i in range(len(a)):
  print(a[i][0],'/',a[i][1],'/',a[i][2], ' ', a[i][3], ':', a[i][4], ' --> ', round(arr[i][0],2), '°F       ', round(arr[i][1]), '%')
```

```
     Date           Time       Temperature    Humidity
2021 / 12 / 15   12 : 24  -->  31.07 °F       49 %
2021 / 12 / 16   12 : 24  -->  31.07 °F       49 %
2021 / 12 / 17   12 : 24  -->  31.07 °F       49 %
2021 / 12 / 18   12 : 24  -->  31.07 °F       49 %
2021 / 12 / 19   12 : 24  -->  31.07 °F       49 %
2021 / 12 / 20   12 : 24  -->  31.07 °F       49 %
2021 / 12 / 21   12 : 24  -->  31.07 °F       49 %
2021 / 12 / 22   12 : 24  -->  31.07 °F       49 %
2021 / 12 / 23   12 : 24  -->  31.07 °F       49 %
2021 / 12 / 24   12 : 24  -->  31.07 °F       49 %
```

Figure 9. *Prediction Table*

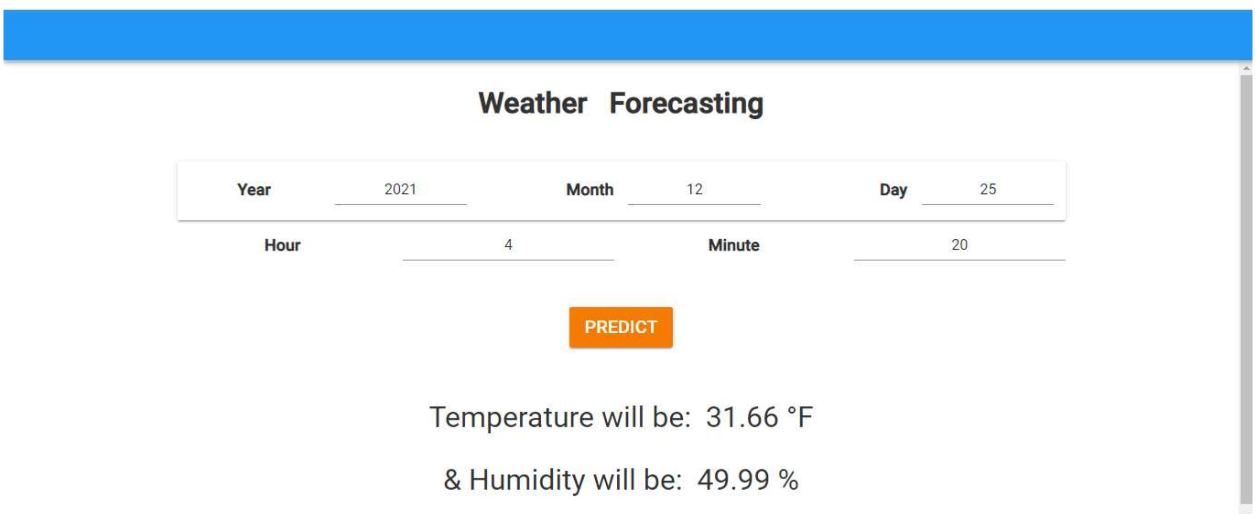

Figure 10. *Web application*

CHAPTER 5: CHARACTERISTICS

1.) Internet of Things

IoT part includes,

- Sensors
- An IoT device

Sensors – Firstly, Measurement of multiple parameters can be done using primary sensing elements or electronic sensors, For Project, DHT22 (Temperature Humidity sensor).

An IoT device – After that, an IoT device is used to establish a stable connection with the Internet. In addition, it can make a connection with any data logger for data-storage and data-analysis.

Generally, DHT22 consists of three pins VCC, Data pin, and GND (ground). Interfacing of DHT22 with ESP8266 can be represented by connecting DHT22 [6].

DHT22	Nodemcu ESP-12E
VCC	VIN
Data pin	D5
GND	GND

Figure 11. *Connection between DHT11 and ESP8266*

2.) Data Logger

The main function of the data-logger is to store the acquired data with respective dates and timestamps in a server-based database as shown in Figure 6. So that it could be accessed remotely. Moreover, based on the collected data logger provides specific features like,

- Graphical Representation,
- On-field and Off-field monitoring,
- Mathematical analytics,
- Future prediction of acquired data.

Google drive comes up with Google spreadsheet in which data can be inserted using Google scripts over a network. Admin can publish Google sheets via Google scripts as a web app [7].

3.) Machine Learning

The main aim of Machine Learning is to observe data and perceive upcoming events. It provides systems the ability to learn automatically and control actions over the measuring variable so that it does not exceed the limit.

The Random Forest algorithm is one of the most popular algorithms that work on a supervised technique. It can be used for both Classification and Regression problems in ML. Above all, it is based on the concept of ensemble learning. In other words, it is a process of combining multiple classifiers to solve a complex problem and to improve the performance of the model [8].

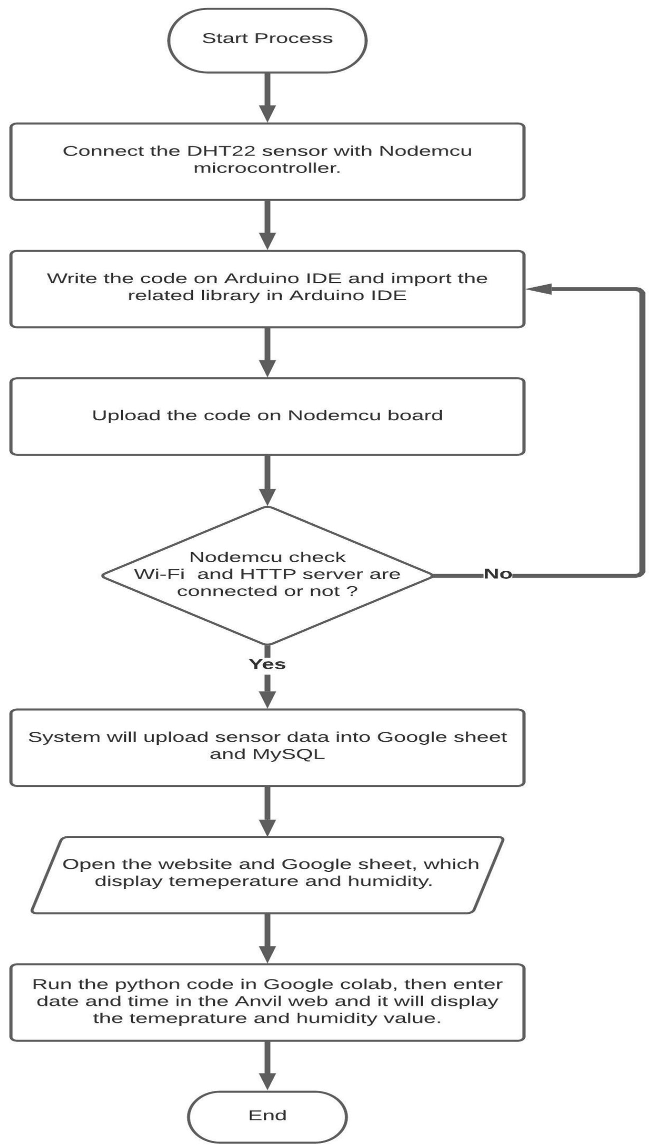

Figure 12. *Flowchart for Hardware System*

CHAPTER 6: CODE IMPLEMENTATION

A. Machine Learning Working

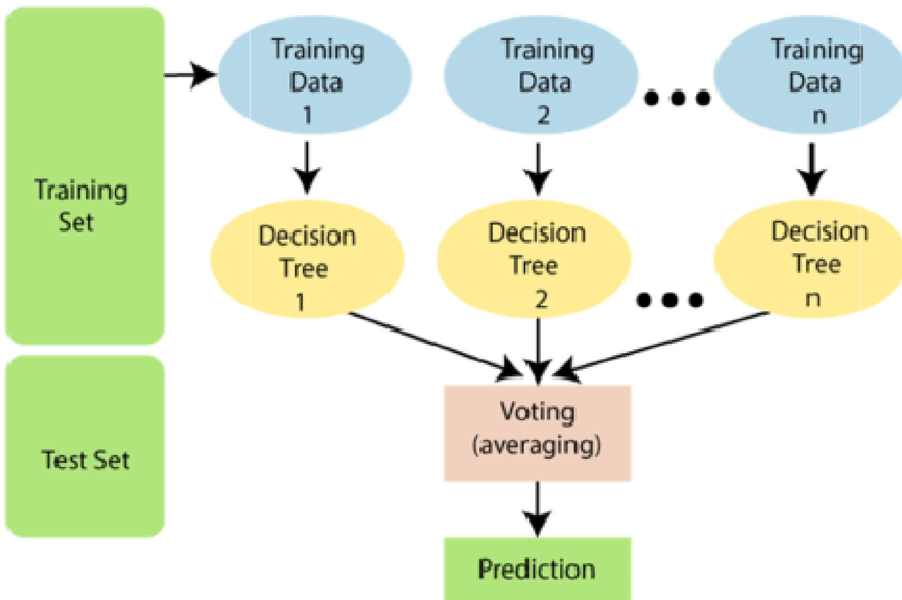

Figure 13. *Working diagram*

Firstly, it applies 75% of the data to the Training set and the remaining 25% of the data to the Test Set as shown in Figure 13. Consequently, the decision tree comes up, and at the end prediction takes place with ±error and specific percent of accuracy.

B. Code Implementation

After that start measurement of the DHT22 sesnor. Measurement of the temperature and humidity includes three parts,

Request to DHT22 – Microcontroller unit (For instance, ESP8266 board) sends low to high pulse as a request to DHT22.

Respond from DHT22 – After receiving the request DHT22 sends low to high pulse as a response to the ESP8266 board.

Data transmission – At last, data transmission from DHT22 to the ESP8266 board will be done in 5 bytes (40 bits). 2 bytes for RH(Relative Humidity), 2 bytes for Temperature, and 1 byte for checksum which checks whether the data is received or not. After making circuit connections as per the circuit diagram given in Figure 6 and managing board and library setting upload the code (given below in APPENDIX) using Arduino IDE into Nodemcu. As a result, we can see output of the code in Serial Monitor of Arduino IDE [9].

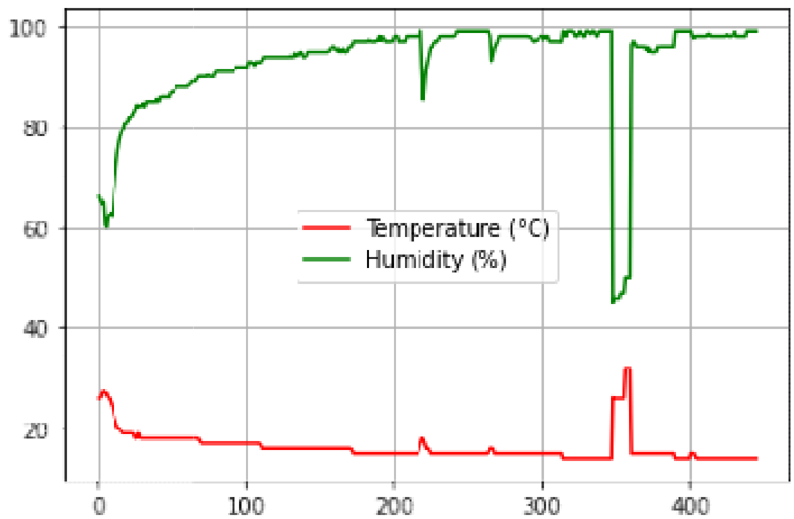

Figure 14. *Graph of data after Transformation*

In the end, after gathering a large amount of the data as a graph shown in Figure 14, apply machine learning online using Python from Google Colab [10]. So basically I have collected the temperature and humidity data of Stony Brook, NY from 15th November 2021 to 22nd November 2021. After that implemented machine learning on that data in python and consequently, made the prediction of the temperature and humidity after Machine Learning as shown an example in Figure 15.

```
prediction = rf.predict(test_features)

errors = abs(prediction - test_labels)

print('Mean Absolute Error', round(np.mean(errors),2), 'degress.')

mape = 100*(errors/test_labels)

accuracy = 100 - np.mean(mape)
print('Accuracy: ', round(accuracy,2), '%.')


a = [np.array([2021,12,i,12,24]) for i in range(40,50)]
arr = rf.predict(a)
```

```
Mean Absolute Error 0.23 degress.
Accuracy:  99.56 %.
```

Figure 15. *Prediction Model*

CHAPTER 7: ADVANTAGES AND DISADVANTAGES

A. ADVANTAGES

1. Military personnel benefit from weather forecasting as they can plan their military activities based on expected weather conditions.
2. Weather forecasting enable people to plan and take precautions against various natural calamities such as flood and typhoon so that to minimize their effects.
3. Weather forecasting enables farmers to adjust their farming activities to suit the expected weather condition.
4. Weather forecasting greatly influences transport, especially in air and water.
5. The weather forecast can help to guide and encourage tourists to visit certain areas.

B. DISADVANTAGES

1. Weather is extremely difficult to forecast correctly.
2. It is expensive to monitor so many variables from so many sources.
3. The computers needed to perform the millions of calculations necessary are expensive.
4. The weather forecasters get blamed if the weather is different from the forecast.

CHAPTER 8: APPLICATIONS

1. Weather analysis and forecasting.
2. Numerical weather prediction.
3. Climate monitoring and prediction.
4. Ecological and environmental monitoring.

CHAPTER 9: CONCLUSION

The real time weather prediction system presented in this project has been developed around low cost IoT board and sensor. The temperature and humidity are the two important parameters that are monitored and uploaded on website cloud [11]. The system has been deployed in an outdoor environment and values of the parameters have been recorded in Google spreadsheet. A Random Forest model has been used in Google Colab environment that is trained with prerecorded values of parameters and used to predict the weather parameters in real time environment.

The project does not require any hard installations and can be easily installed in old installations. So, it is easily compatible with old systems. Since it is a prediction based and thus doesn't require any extra cost of installing software. It will be efficient for many weather monitoring stations and will help in having an alternative solution when there is an absence of the high cost weather monitoring setup. The rainfall prediction is done with the use of machine learning in minimal costs. The complete weather forecasting setup is flexible enough to be installed anywhere and make weather predictions without much historical experience [12]. Further, the system can be modified to be used at commercial level and have many applications in smart homes, buildings, sports, hospitals etc.

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