

IOT Based Weather Monitoring & Analysis

Using GUI

Adesh Dhage

Department of E&TC, Pimpri Chinchwad College of
Engineering and Research, Ravet,
Pune, India

adesh.dhage_entc21@pccoer.in

Rohan Yadav

Department of E&TC, Pimpri Chinchwad College of
Engineering and Research, Ravet,
Pune, India

rohan.yadav_entc21@pccoer.in

Yogesh Pawar

Department of E&TC, Pimpri Chinchwad College of
Engineering and Research, Ravet,
Pune, India

yogesh.pawar_etc2020@pccoer.in

Dipali Shende

Department of E&TC, Pimpri Chinchwad College of
Engineering and Research, Ravet,
Pune, India

dipali.shende@pccoer.in

Abstract— Weather forecasting is the application of science and technology to predict the state of the atmosphere at a particular location. The majority of early weather forecasting techniques were based on pattern identification, or the observation of recurring patterns in the events. For instance, one may notice that an especially crimson sunset typically heralded favorable weather the next day. Not all of these forecasts, though, turn out to be accurate. Here this system will predict weather based on parameters such as temperature, humidity, wind speed, rain gauge, wind direction, soil temperature, atmospheric pressure, soil moisture. We will collect the weather data with the help of some sensors and pass it to the system. System will take this parameter and will predict weather from previous data in database(dataset). The primary objective of our project is to develop a well- made and accurate weather forecasting model capable of predicting climate changes over extended periods and assessing their implications for future generations. The weather forecasting system forecasts weather based on historical records; thus, this prediction will prove to be trustworthy. It takes into account elements like temperature, humidity, wind speed, rain gauge, wind direction, soil temperature, atmospheric pressure, soil moisture. Air traffic, maritime, agriculture, forestry, military, navy, and other fields may all use this technology.

Keywords— BME280, Rain Gauge Sensor, Soil Moisture Sensor, Wind Direction Sensor, Wind Speed Sensor, ESP32 Controller, Linear Regression, AWS, Graphical User Interface.

I. INTRODUCTION (HEADING 1)

According The Indian economy's most significant sector is agriculture. Fifty percent of India's workforce is employed in the agriculture industry, which generates eighteen percent of the country's GDP. The world's top producer of wheat, rice, pulses, spices, and spice-related items is India. The weather is a vital natural element for life; depending on its severity, it may either provide or destroy opportunities for survival. To put it simply, weather forecasting is the process of predicting the state of the atmosphere in a given location at a given time utilizing physics principles, technology, and a range of statistical and empirical methodologies. The weather prediction is incredibly helpful in protecting both people and property and to protect the crops and it will tell us what to expect in our atmospheric environment. Weather prediction data is essential for making quick modifications to daily agricultural activities, which reduces losses due to

unfavorable weather conditions and raises the quantity and quality of agricultural output. aids in seasonal or long-term planning as well as crop selection according to ideal weather conditions. Seasonal forecasting contributes to the betterment of farmers lives in areas where there is significant fluctuation in yearly rainfall. Seasonal forecasts play an important role in deciding the eco- nomic policies of governments, during major drought was forecasted, monetary policy could be relaxed to maintain growth targets. The unique aspect of our approach is that ability to provide fast and reliable forecasts while operating on low-cost and resource- efficient computing systems. These forecasts have practical applications in our daily lives, enabling us to make informed decisions and adapt effectively to changing weather conditions. This paper presents the review on the various methods of Weather Forecasting. It focuses on the accurate weather prediction using advance IOT[1] and Machine Learning model[5][6] which predicts the Realtime weather conditions at max accuracy and this data is displayed on the dashboard.

II. LITERATURE REVIEW

1] Gaurav Verma, Pranjul Mittal, Shaista Farheen (Department of Electronics Communication) Dayananda Sagar College of Engineering/ "Real Time Weather Prediction System Using IOT and Machine Learning"/ IEEE 2020 - Methodology Used 'Logistic Regression Model', Parameters 'Temp., Humidity, Light Intensity', Conclusion 'By using sensors machine Learning module trained with prerecorded data and predict weather forecast'. — The emphasis of today is on intelligent technologies, such as machine learning and the Internet of Things. There are numerous IoT implementations available for IoT hardware platforms. Among them is the ESP8266 chip. This study creates a real-time weather prediction system that may be used to forecast the weather in a variety of settings, including residences, businesses, stadiums, and agricultural settings. The system makes use of an LDR light intensity sensor and a DHT11 temperature and humidity sensor. Using an ESP8266-01 module and NodeMCU, the sensed data from the sensors is uploaded to a ThingSpeak cloud server.

2] Dires Negash Fente, Prof. Dheeraj Kumar Singh, (Department of Information technology, Parul University

Parul Institute of Engineering and Technology)/ “Weather Fore- casting Using Artificial Neural Network”/ IEEE 2018 - Methodology Used ‘LSTM – Long short-term Memory’, Parameters ‘Temp., Humidity, Light Intensity, Wind Speed, Wind Direction’, Conclusion ‘LSTM gives Result with High Accuracy’. Since the weather has a major impact on the agricultural and industrial sectors, accurate weather forecasting is essential in today's society. Additionally, it is employed to predict and warm up natural disasters. Determining the appropriate values for weather parameters and projecting future weather conditions based on these factors is known as weather forecasting. In this study, several meteorological parameters were gathered from the National Climate Data Center, and the neural network was trained for various combinations using the long-short term memory (LSTM) technique.

3] Sushmitha Kothapalli, S. G. Totad, (Dept of Computer Science and Engineering) “A Real-Time Weather Forecasting and Analysis”/ IEEE 2017 - Methodology Used ‘ARIMA Model’, Parameters ‘Temp., Humidity, Light Intensity, Wind, Rainfall’, Conclusion ‘Val- ues are Predicted by implementing ARIMA Model using R Studio’. - The endeavor of meteorologists to anticipate the weather and potential outcomes at a future date is known as weather forecasting. Temperature, wind, humidity, rainfall, and data set size are the factors that determine the climatic state parameters. In this case, only the parameters of temperature and humidity are taken into account for the experimental study. The DHT11 sensor, which aids in determining the temperature and humidity values of a certain region or location, provides the temperature and humidity data that is gathered. Using an Ethernet shield to facilitate online data uploading, the raspberry pi is utilized to save the gathered data on the cloud.)Shivam Tandon, Abhishek Patel, Pawan Kumar Singh (School of Computing Scienceand Engineering Galgotias University Uttar Pradesh, India/ “Weather Prediction Us- ing Machine Learning Algorithms”/ IEEE 2020 - Methodology Used ‘Random Forest, Decision Tree, MLP Classifier, Linear Regression’, Parameters ‘Temp., Humidity, Light Intensity, Wind, Rainfall, Visibility’, Conclusion ‘By using Machine Learning Module gives Accurate Result’. — Climate plays a crucial role in numerous important production industries, such as agriculture. These days, there is a strong emphasis on climate change, which is why historical weather forecasts are becoming less accurate and more accurate. For this reason, miles play a crucial role in customizing and adjusting the weather forecast model. Both the nation's financial system and people's lives are impacted by those forecasts. A forested area utilized for weather forecasting is part of an information and statistics analysis algorithm system. One of the strongest natural barriers we face in life is the weather; we must consider factors such as humidity, temperature, and other forms of protection. astounding. Our artwork aims to format weather predictions in an efficient manner.

4] Tulsi Pawan Fowdur, Rosun Mohammad Nassir-Ud-Diin Ibn Nazir (Department of Electrical and Electronic Engineering, University of Mauritius, Reduit, Mauritius)/ “A real-time collaborative machine learning based weather forecasting system with multiple predictor locations” – Weather forecasting is an essential application in meteorology and has been one of the world's most technically and technologically difficult topics. As the devastating repercussions of climate change continue to unfold, accurate localized short-term weather prediction has become more vital than ever. In this research, we present a collaborative machine learning-based real-time weather forecasting system that uses data from several places to predict the weather for a single site. Five machine learning algorithms were utilized in this work, and tests were conducted in four distinct sites in Mauritius to forecast weather. Temperature, wind speed, wind direction, pressure, humidity, and cloudiness are all variables to consider. The Open Weather API was used to collect the weather data.

5] A THESIS Submitted by - KALA A (Faculty of Information Communication Engineering ANNA UNIVERSITY CHENNAI)/ “Hybrid Weather Forecasting Models Based On Deep Learning And Mode Decompositions Methods”/ Shodhganga 2022 - Methodology Used ‘Artificial Neural Network, hybrid model based on long-short term memory the artificial algae algorithm (LSTM Model)’, Result Component ‘Result Shows that hybrid performance model perform a better prediction in comparison with LSTM.’, Future Scope ‘It could be extended to forecast other events such as drought and flood’ & The suggested hybrid models may be expanded to predict additional occurrences like floods and droughts. It is possible to create a hybrid model for drought forecasting that blends linear and nonlinear models by treating the frequency and intensity of droughts as random events.

6] A THESIS Submitted by - Uma Sharma (Faculty of Mathematics Computing Banasthali Vidyapith Rajasthan, India)/ “Smart Weather Forecasting Using Deep Learning”/ Shodhganga 2022- Methodology Used ‘Bi-LSTM Model for historical weather data. Based on ARIMA Model and Deep Learning Model CRNN’, Result Component ‘Increasing the size of training data sample cloud result in better prediction and deep learning produce accurate result.’, Future Scope ‘Combining different local Weather station data regional weather data for an accurate prediction’ and Seven distinct surface weather parameters are used in this study. Higher input counts would most likely produce better outcomes. But doing so will make the model more complicated and need estimating a lot more parameters. Furthermore, the suggested model is trained using 70% of the entire meteorological data collected during a mere 2792 days. A deeper learning network may be predicted more accurately by expanding the training data sample. More data may be used to refine the developed model and improve its performance. By adding more meteorological characteristics, such as soil temperature, soil moisture, snow, solar radiation balance, and pressure at various levels, it could be possible to enhance the forecast.

7] A THESIS Submitted by - VASAVI RAVURI (Research Development Jawaharlal Nehru Technological University)/ "Optimized Deep LSTM Based Ensemble Classifier for Weather Forecasting"/ Shodhganga 2023 - Methodology Used 'Use of big data Clustering using Spark. Prediction weather with MFATA – based deep LSTM using time series.', Result Component 'It produce very accurate result depending on size of data efficiency.', Future Scope 'Interfacing IOT Sensors increase more efficiency using data mining tech' and The goal of this effort is to anticipate weather properly in situations where there is a sudden shift in the pattern of the weather. We applied the idea of reciprocal connection between meteorological variables to solve this issue. In order to predict a single output feature, we presented our innovative SFA-LSTM model in this study. It has an integrated spatial feature attention mechanism that allows it to capture long-term dependencies and spatial feature correlations of multivariate input time series. When abrupt changes in input sequences are seen, the spatial feature attention mechanism accurately predicts the future by understanding the quantitative mutual effect of input characteristics on target features. Simultaneous shifts noticed in following weather variables that are mutually connected can be used to determine the extent of a weather feature shift. The weight of each geographic feature's effect from multiple weather variables on the target variable may be ascertained by using multivariate weather variables to forecast a single target weather characteristic. Accurately forecasting future weather over extended periods of time is aided by capturing these relationships during model learning. The suggested model was constructed using an encoder-decoder architecture, in which spatial relations are learned in the decoder phase and temporal dependencies in the data are learned in the encoder phase using LSTM layers. SFA-LSTM is seen to provide correct spatial feature interpretability, outperforming the performance of the state-of-the-art models.

III. GAP IDENTIFICATION

Sr. No	Journal Name	Gap/Limitations
1.	Real time weather prediction system using IOT and Machine Learning	By using sensors & machine Learning module trained with prerecorded data and predict weather forecast but it not gives Realtime forecast.
2.	weather forecasting using Artificial Neural Network	LSTM gives Result with High Accuracy but by using linear regression it gives high accuracy.
3.	Realtime weather forecasting and Analysis	Values are Predicted by implementing ARIMA Model using R Studio.
4.	A real-time collaborative machine learning based weather forecasting system with multiple predictor locations	By using Machine Learning Module gives Accurate Result but It can trained better to achieve max accuracy.
5.	Hybrid weather Fore casting models based in deep learning and mode decomposition methods	It could be extended to forecast other events such as drought and flood.
6.	smart weather forecasting using deep learning	Combining different local Weather station data & regional weather data for an accurate prediction
7.	Optimized Deep LSTM Based Ensemble Classifier for Weather Forecasting	Interfacing IOT Sensors increase more efficiency using data mining tech.

IV. GENERALIZED METHODOLOGY

In this project, our primary objective is to create a comprehensive weather monitoring and prediction system for agricultural purposes. To achieve this, we will follow a structured approach according to flowchart:

- **Data Collection:** Initially, we will gather weather-related data using various sensors. Specifically, we will use to measure parameters such as temperature, humidity, wind speed, rain gauge, wind direction, soil temperature, atmospheric pressure, soil moisture by using specific sensors.
- **Data Transmission:** We will employ a ESP32 to upload the collected data to a central server. This server acts as a repository for the weather data, ensuring its availability for analysis and prediction.

- **Machine Learning Model:** Our next step involves building a machine learning model, specifically employing linear regression. To train this model, we will utilize historical weather data from the past five years. This process allows the model to master and understand the relationships between various weather parameters.

- **Data Comparison and Prediction:** Once the machine learning model is trained, it will retrieve the live data uploaded to the server. It will then compare this real-time data with historical data from the sensors. Using the insights gained from the training, the model will generate accurate weather predictions.

- **Web GUI Display:** The final step is to display these predictions in a user-friendly manner through a web-based graphical user interface (GUI). Users can use this user interface to view the current weather conditions and forecasts, which are generated by the machine learning model's analysis of live and historical data.

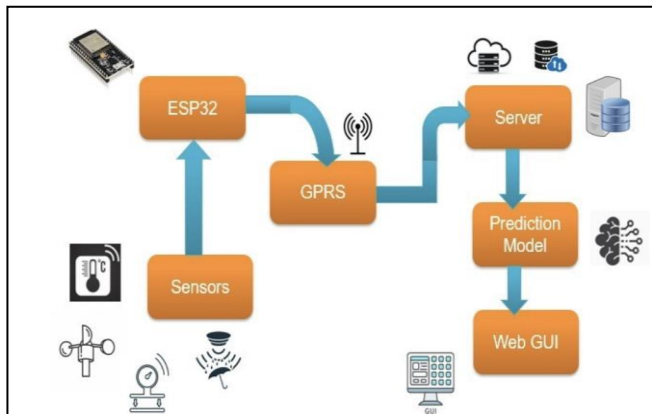


Fig. 1. Block Diagram

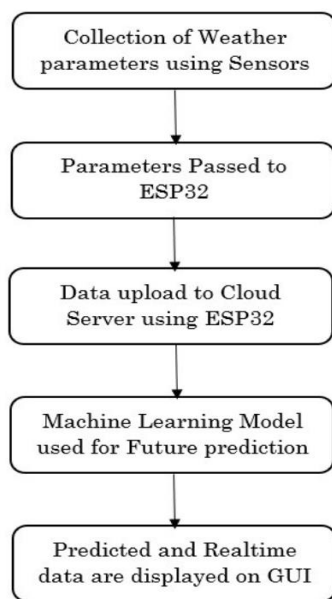


Fig. 2. Flowchart

V. Hardware Components & Software Specification

1. BME280 Sensor

You may use BME280 (datasheet, Adafruit)[1] humidity, pressure, and temperature sensors with ESP32 Home by using the bme280 sensor platform. The sensor is utilized in forced mode, which involves taking a measurement and then putting it to sleep until the next measurement. For this sensor to function, the I2C has to be configured in your setup.



Fig. 3. BME280 Sensor

2. Rain Gauge Sensor

A clever and reasonably priced rain detection gadget is the rain drop sensor module.[1] It consists of a control board and a rain detecting pad. The control board receives these signals and has the ability to binarize them, while the sensitive sensor pad detects the presence of any water on it. The automotive sector is one of the main applications for the rain drop module. When rain is detected, it may be used to monitor the weather and request that shutters or windows be closed. This is a handbook to assist in creating our project.

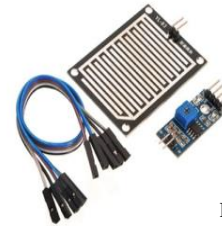


Fig. 4. Rain Gauge Sensor

3. Wind Speed Sensor

One device that measures wind speed is the three cups type Wind Speed Sensor Voltage Type (0-5V) Anemometer Kit. It is made up of the circuit module, wind cup, and shell. The internal drive integrates photovoltaic modules, an industrial microcomputer processor, a current generator, electric current and other components. The sensor shell and wind cups are made of an aluminum alloy that is carefully cast using a unique mold technique, resulting in extremely tiny tolerances. The sensor has a high strength, is waterproof, resistant to corrosion, and has an internal circuit that has been protected. The surface precision is also quite good. The cable's plug is a military plug with strong anticorrosive and erosion-prevention capabilities. In the event that pertinent standards are applied to guarantee the correctness of the wind speed acquisition, it can guarantee the instrument employed for an extended period of time. Military-grade A material makes up the circuit PCB, ensuring both the quality and stability of the electrical qualities. All electronic components are industrial chips, which ensure that the host can function correctly at temperatures between -20°C and 50°C and humidity levels between 35% and 85% (condensation). Overall, these chips have incredibly dependable electromagnetic interference resistance.



Fig. 5. Wind Speed Sensor

4. Wind Direction Sensor

The FST200-202 wind direction sensor is utilized in several domains, including meteorology, environment, ropeway, greenhouse, and breeding, to determine the direction of wind. Alloy materials with surface treatment are used to make the major structural components. The product resists corrosion and is waterproof well. Since all of the internal and rotational components are sealed, water, salt spray, and sand dust entry may be successfully avoided.



Fig. 6. Wind Direction

5. Soil Moisture Sensor

The two probes that make up the soil moisture sensor are used to determine the volume of water in the soil. In order to assess the moisture content, the two probes let current flow through the soil and then obtain the resistance value. There will be less resistance when there is more water since the soil will conduct more electricity. As a result, there will be more moisture present. Since dry earth doesn't carry electricity well, when because the soil will conduct less electricity when there is less water present, there will be greater resistance. As a result, there will be less moisture.

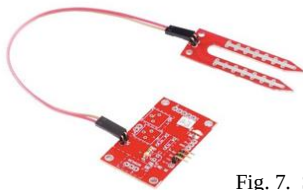


Fig. 7. Soil Moisture

7. ESP32 Controller

The ESP32 line of low-cost, low-power system-on-a-chip microcontrollers has dual-mode Bluetooth and integrated Wi-Fi. The ESP32 series incorporates built-in antenna switches, power amplifier, low-noise receive amplifier, filters, and power-management modules. It uses either a Tensilica Xtensa LX6 microprocessor in both dual-core and single-core variations, Xtensa LX7 dual-core microprocessor, or a single-core RISC-V microprocessor. The Shanghai-based Chinese business Espressif Systems designed and developed ESP32, which is produced by TSMC utilizing their 40 nm technology. It is the ESP8266 microcontroller's replacement.



Fig. 8. ESP32

7. Machine Learning Algorithm

Linear Regression is a supervised learning algorithm that falls under the category of machine learning. Its primary objective is to perform regression tasks by modeling a target prediction value using independent variables. This algorithm is commonly employed to determine the relationship between variables and make accurate forecasts. The various regression models available differ based on the type of relationship they consider between dependent and independent variables, as well as the number of independent variables utilized.

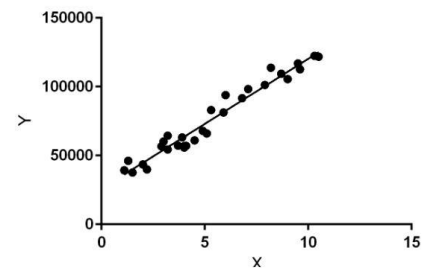


Fig. 9. Linear Regression Graph

8. AWS Server

Amazon.com offers Amazon Web Services (AWS), a prominent cloud computing platform that delivers various services such as computing power, storage solutions, networking, databases, machine learning, and more. These services are accessible through a secure and scalable cloud infrastructure. AWS enables users to efficiently deploy, oversee, and expand applications and services worldwide, with costs based on actual resource consumption. The platform's flexibility, reliability, and scalability make it a preferred option for startups, corporations, and governmental organizations seeking to enhance and expand their digital projects.

8. GUI

To develop a dashboard that presents real-time weather conditions, Grafana and MySQL can be utilized as essential elements of the solution. The initial step involves configuring MySQL as the database to house weather-related information, such as temperature, humidity, wind speed, and precipitation metrics. By integrating a weather API, the most recent data can be regularly retrieved and stored in the MySQL database. Subsequently, Grafana should be installed and configured to establish a connection with the MySQL database as a data source. Leveraging Grafana's user-friendly interface, users can create personalized dashboards that exhibit weather metrics through diverse visualization panels like graphs, tables, and gauges. By crafting SQL queries within Grafana, specific weather data can be extracted, and the dashboard layout can be tailored to effectively present information. Additionally, users have the option to configure alerts that notify them of critical weather conditions. It is imperative to continuously assess and enhance the dashboard to ensure its precision and user-friendliness, facilitating the acquisition of valuable insights into real-time weather patterns and trends.

IV. CONCLUSION

In the development of this IoT-based weather prediction initiative, we begin by selecting appropriate sensors and a microcontroller for efficient data collection, ensuring connectivity to the internet for smooth data transmission. The gathered data is then forwarded to a cloud platform for processing, encompassing tasks such as data cleansing and feature extraction. Employing machine learning methodologies, we train models to forecast real-time weather conditions. The system incorporates a user-friendly interface for displaying both current and predicted weather details. An integrated alert system is designed to notify users of extreme weather events, offering valuable early warnings for potential climate shifts. Prior to implementation, rigorous testing is conducted to verify the system's reliability and efficacy, particularly in the context of safeguarding against environmental challenges, notably in agriculture. Additionally, the GUI simplifies data interpretation, making it user-friendly for individuals with varying technical expertise. In conclusion, this innovative solution contributes to efficient weather monitoring, analysis, and decision-making without the risk.

V. REFERENCES

- [1] Gaurav Verma, Pranjul Mittal, Shaista Farheen (Department of Electronics & Communication) Dayananda Sagar College of Engineering/ "Real Time Weather Prediction System Using IOT and Machine Learning"/ IEEE 2020 <https://ieeexplore.ieee.org/document/9182766>
- [2] Dires Negash Fente, Prof. Dheeraj Kumar Singh, (Department of Information technology, Parul University Parul Institute of Engineering and Technology)/ "Weather Forecasting Using Artificial Neural Network"/ IEEE 2018 <https://ieeexplore.ieee.org/document/8473167>
- [3] Sushmitha Kothapalli, S. G. Totad, (Dept of Computer Science and Engineering) "A Real-Time Weather Forecasting and Analysis"/ IEEE 2017 <https://ieeexplore.ieee.org/document/8391974>
- [4] Shivam Tandon, Abhishek Patel, Pawan Kumar Singh (School of Computing Science and Engineering Galgotias University Uttar Pradesh, India/ "Weather Prediction Using Machine Learning Algorithms"/ IEEE 2020 <https://ieeexplore.ieee.org/document/9862337>.
- [5] Tulsi Pawan Fowdur, Rosun Mohammad Nassir-Ud-Diin Ibn Nazir (Department of Electrical and Electronic Engineering, University of Mauritius, Reduit, Mauritius)/ "A real-time collaborative machine learning based weather forecasting system with multiple predictor locations"/ journal homepage: www.sciencedirect.com/journal/array.
- [6] A THESIS Submitted by - KALA A (Faculty of Information & Communication Engineering ANNA UNIVERSITY CHENNAI)/ "Hybrid Weather Forecasting Models Based On Deep Learning And Mode Decompositions Methods"/ Shodhganga 2022 <http://hdl.handle.net/10603/477722>.
- [7] A THESIS Submitted by - VASAVI RAVURI (Research Development Jawaharlal Nehru Technological University)/ "Optimized Deep LSTM Based Ensemble Classifier for Weather Forecasting"/ Shodhganga 2023 <http://hdl.handle.net/10603/477722>.