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Integrated IoT Based Weather Monitoring and Machine Learning Weather Prediction System

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Abstract: This project presents an Integrated IoT based Weather Monitoring System and Machine Learning based Weather Prediction System that integrates real-time sensor data collection through sensors and predictive analysis to implement weather prediction. The system includes IoT sensors like BME680, Wind Speed and Direction and Rainfall sensors to collect real-time parameters like temperature, humidity, wind speed which is sent over to the cloud NodeMCU-ESP32 over Wi-fi and is also stored in a cloud storage platform (OneDrive). The data is then visualized and monitored on open-source platform called ThingsBoard. To enhance the project, we implemented Machine Learning Algorithms, Random Forest Regressor for temperature prediction and Random Forest Classifier for rain prediction. The models are trained on the historical data and also real-time data to increase accuracy of prediction. This predicted data is displayed the ThingsBoard dashboard for user accessibility. This cost-effective, scalable and efficient system focuses on weather monitoring and prediction to increase the accuracy and making it more valuable for applications like Air Quality Monitoring, Disaster Management and many more.
Keywords: IoT; Machine Learning; Weather Monitoring; Prediction; ThingsBoard

I. INTRODUCTION

In today’s world Weather Monitoring and Predictions are essential for various sectors like agriculture, disaster management and urban planning. The systems present in the market implement traditional methods like manual data collection and analysis through satellites or mathematical formulas which is time consuming and prone to errors leading to less accurate predictions.

This System is designed to overcome the limitations faced by these conventional methods. The system comprises of IoT sensors to collect real-time weather data- temperature, humidity, aqi, wind speed and direction- which is stored in excel sheet in csv format and also sent to Cloud via MQTT protocol to the ThingsBoard server for monitoring on an interactive dashboard. For weather prediction. Machine learning models- Random Forest Classifier and Random Forest Regressor is used for prediction of temperature, humidity, rain for the next five hours. The model is trained on historical data of last two years obtained from OpenWeather API and the real-time data that was stored in csv format from OneDrive ensuring reliable and precise predictions. The predicted results are then displayed on the ThingsBoard dashboard allowing user to visualize future weather trends alongside live data.

By combining two emerging trends- IoT and ML, this system improves efficiency and accuracy of weather monitoring and prediction. It also demonstrates the potential of this system in developing applications like air quality monitoring, disaster management and alert systems for users.

II. LITERATURE REVIEW

Several studies have explored the implementation and impact of IoT- based weather monitoring and prediction systems, leveraging advancements in sensor technology, cloud computing, and machine learning. These works have laid the foundation for developing efficient and scalable solutions for real-time data collection and analysis.

In a similar vein, Mohit Tiwari et al. [1] proposed a weather monitoring system that integrates Internet of Things (IoT) technology with cloud computing to collect and analyze real-time meteorological data. Key features of their system include the deployment of various sensors to monitor environmental parameters such as temperature, humidity, and atmospheric pressure. The data collected is transmitted to a cloud platform for processing, enabling real-time access and analysis. Their work demonstrates the potential of IoT and cloud-based systems in improving the accuracy and accessibility of weather data. The primary advantage of their approach is its scalability and ability to provide real-time insights, making it suitable for applications in agriculture, disaster management, and urban planning.

G.A. Girija C et al. [2] developed an IoT-based weather monitoring system that focuses on real-time collection and analysis of meteorological data to enhance weather forecasting accuracy and accessibility. The system incorporates various environmental sensors to monitor key parameters such as temperature, humidity, rainfall, and atmospheric pressure.

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Their research emphasizes the role of IoT in enabling precise and timely weather predictions, which are critical for applications in agriculture, disaster management, and urban planning. The advantage of their system is its ability to provide accurate and localized weather forecasts, improving decision-making in weather- sensitive industries.

Rahut et al. [3] proposed a Smart Weather Monitoring and Real-Time Alert System Using IoT, which focuses on providing real-time weather updates and alerts to users. Their system integrates IoT sensors with a cloud-based platform to monitor parameters such as temperature, humidity, and rainfall. The system also includes an alert mechanism to notify users of extreme weather conditions. The key advantage of their work is its emphasis on real-time alerts, making it highly useful for disaster management and emergency response.

These studies collectively underscore the significance of integrating IoT, cloud computing, and machine learning in developing advanced weather monitoring and prediction systems. Building on these foundations, this project aims to further enhance the capabilities of such systems by incorporating machine learning models for predictive analytics and leveraging cloud platforms for real-time data visualization.

III. METHODOLOGY

This section describes the approach used to develop Integrated IoT based Weather Monitoring and ML based Weather Prediction System. It includes system architecture, IoT implementation, ML implementation and lastly integration and flow of real-time and predictive data.

A. System Architecture

This system is divided into three main parts-

1) IoT based Weather Monitoring
2) ML based Weather Prediction
3) Cloud based Data Monitoring on ThingsBoard Platform

The overall methodology is illustrated in Figure 1.

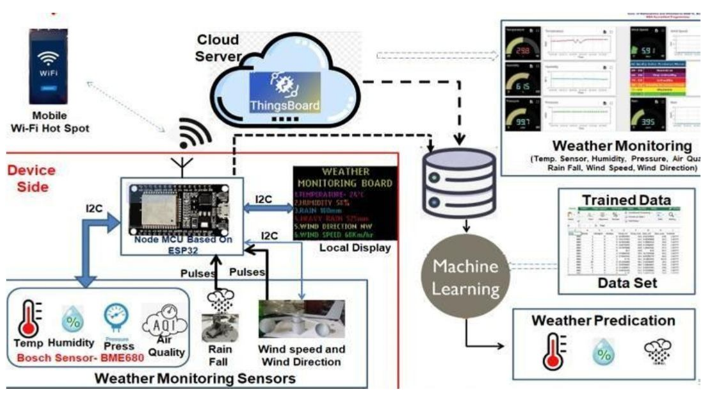

Figure 1 System Architecture of Weather Monitoring and Weather Prediction System

The flow of this system is as follows- The various sensors like BME680, Rainfall Sensor, Wind Speed and Direction Sensor is connected to the NODEMCU-ESP32. It collects the real-time weather data like temperature, humidity, air pressure, rainfall, wind speed and direction. This data is sent over to the cloud via MQTT(Message Queueing Telemetry Transport Protocol) onto the open source platform called ThingsBoard for visualization for user weather monitoring. This data is also stored in the Excel sheet in csv format and uploaded on one drive for machine learning purposes. The user can easily perform Wetaher Monitoring on ThingsBoard platform.

Now for Weather Prediction, the machine learning algorithms used are Random Forest Classifier for rain prediction and Random Forest Regressor for temperature and humidity prediction for the next five hours.

The model is trained using historical data fetched from OpenWeather API and the real-time data collected from our IoT system fetched from the one drive for more accurate predictions. The predicted results are then displayed on the ThingsBoard dashboard allowing user to visualize future weather trends alongside live data

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B. IoT based Weather Monitoring

The weather monitoring system is built using a network of sensors connected to the NODEMCU-ESP32 microcontroller, which acts as the central unit for data collection and transmission. The system includes several sensors, such as the BME680 for measuring temperature, humidity, air pressure, and AQI, along with a rainfall sensor and wind speed & direction sensors. These sensors communicate with the ESP32 via the I2C protocol, ensuring seamless and efficient data acquisition.

Once the sensors gather real-time data, the ESP32 processes the readings and displays them on a local display module. For better visualization and monitoring, we use ThingsBoard, an open-source platform that provides easy access to real-time data. To enable weather prediction, all sensor readings are stored in a CSV file on OneDrive, ensuring accessibility for further processing with machine learning models.

C. ML based Weather Prediction

The system leverages two machine learning models to enhance weather prediction capabilities: the Random Forest Regressor and the Random Forest Classifier. The Random Forest Regressor is used to predict continuous values, such as temperature and humidity levels, while the Random Forest Classifier categorizes weather conditions into distinct classes, such as "humid" or "dry" based on predefined thresholds.

These models are trained on historical weather data, enabling them to identify patterns and relationships among various weather parameters. Their performance is evaluated using standard metrics, including Root Mean Square Error (RMSE) and Mean Absolute Error (MAE), ensuring robust and reliable predictions. Once trained, the models can forecast temperature and humidity levels for the next five hours, providing a data-driven and intelligent approach to weather monitoring.

D. Cloud based Data Monitoring on ThingsBoard Platform

The integration of IoT and machine learning ensures a seamless data flow between real-time monitoring and predictive analytics. Weather data collected by IoT sensors is continuously transmitted to the cloud storage, where it is processed and prepped for machine learning analysis. The trained machine learning models receive this real-time data input, analyse trends, and generate predictions based on the learned patterns from historical data and real-time data.

The predicted temperature and humidity values are then transmitted to the ThingsBoard cloud platform. This integration enables real-time visualization of both current and forecasted weather conditions, providing users with an interactive and dynamic monitoring experience.

IV. DEVICE ARCHITECTURE AND COMPONENTS

The device architecture of the proposed system as shown in Figure 4 integrates IoT-enabled sensors with cloud-based data processing and machine learning algorithms to enhance weather monitoring and prediction. The system consists of multiple components working in synergy to collect, transmit, analyze, and visualize real-time meteorological data.

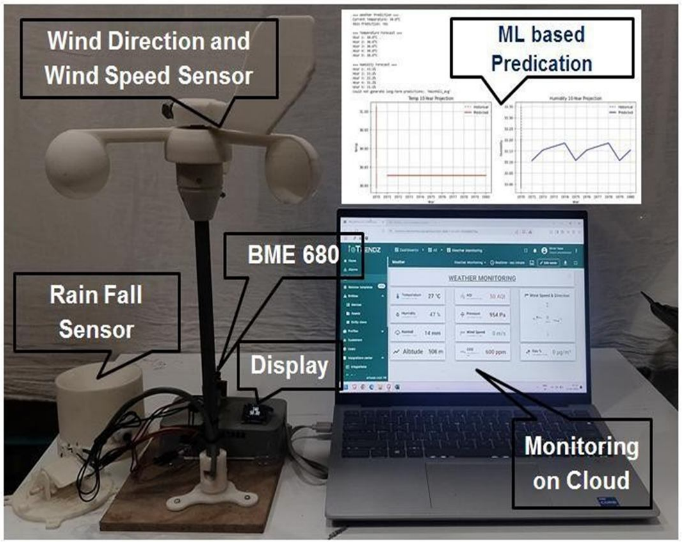

Figure 2 Device Architecture of Weather Monitoring and Weather Prediction System

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The components used in the system as structured in Table 1

Table 1 Components used in Weather Monitoring and Prediction System

Component	Specification/Model	Function
Microcontroller	NODEMCU-ESP32	Collects data from sensors, processes it, and transmits it to the cloud.
Temperature, Humidity, Air Pressure, and AQI Sensor	BME680	Measures temperature, humidity, air pressure, and air quality index.
Rainfall Sensor	YF-S201 or Equivalent	Detects the amount of rainfall by measuring water accumulation.
Wind Speed Sensor	Anemometer (Analog/Digital)	Measures the speed of the wind.
Wind Direction Sensor	Wind Vane (Analog/Digital)	Determines the direction from which the wind is blowing.
Local Display Module	OLED Display (SSD1306) or LCD 16x2	Displays real-time environmental parameters locally on the device.
Cloud Platform	ThingsBoard (Open-source IoT platform)	Provides real-time visualization, monitoring, and analysis of sensor data.

V. RESULTS

The IoT-based weather monitoring system successfully predicts temperature and humidity trends for the next 5 hours. The results are shown in graphical format to provide a clear understanding of the variations.

A. *Temperature Forecast*

- The 5-hour temperature prediction is shown in Figure 3.
- The temperature initially drops sharply around 20:35, reaching its lowest point of approximately 26°C.
- After this dip, it rises again to 28.5°C at 21:35, followed by a minor drop at 22:35, and then increases again, reaching 29°C at 23:35.
- This pattern indicates temperature fluctuations over time, which could be influenced by external weather conditions.

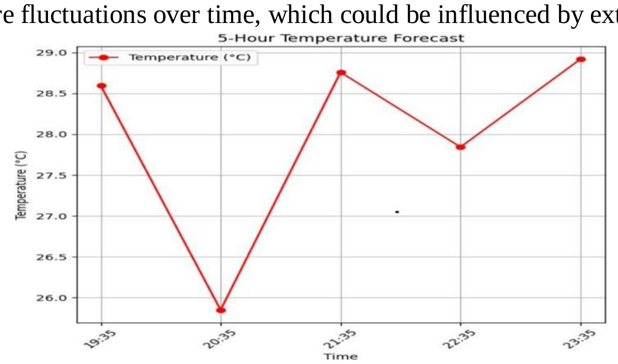

Figure 3 5-Hour Temperature Forecast

B. *Humidity Forecast*

- Figure 4 shows the predicted humidity levels for the next 5 hours.
- Initially, humidity is around 30% at 19:35, but there is a sharp rise to 47.5% by 20:35.
- After this sudden increase, humidity remains constant at approximately 47.5% for the rest of the forecasted period.
- The steady humidity levels suggest stable atmospheric moisture after an initial rise.

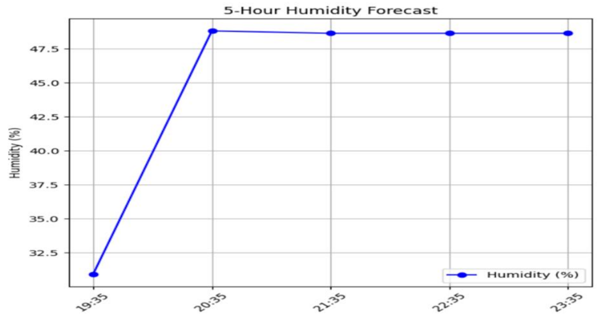

Figure 4 5-Hour Humidity Forecast

C. System Accuracy and Performance

- The machine learning model effectively captures changes in temperature and humidity, making it useful for real-time weather monitoring.
- While temperature values fluctuate, humidity shows a rapid increase followed by stability.
- The system's ability to track these variations in real-time proves its potential for environmental monitoring and weather prediction applications.

VI. CONCLUSION

The Integrated IoT-Based Weather Monitoring and Machine Learning Weather Prediction System successfully combines real-time data collection, cloud-based visualization, and AI-driven forecasting to enhance weather monitoring accuracy. The system fetches live weather data from OneDrive, processes it using machine learning models, and predicts temperature and humidity trends for the next five hours. These forecasts are then sent back to the ThingsBoard cloud platform, allowing seamless real-time monitoring and visualization. The results indicate that the proposed system provides reliable short- term weather predictions, which can be beneficial for climate monitoring, agricultural planning, and disaster preparedness. By leveraging IoT and cloud computing, the system ensures scalability and accessibility, making it adaptable to different environments.

VII. FUTURE SCOPE

The IoT-Based Weather Monitoring and ML Prediction System lays a strong foundation for real-time weather data collection and forecasting, with potential for further enhancements to improve accuracy and efficiency:

1) Integration of Additional Sensors – Expanding sensor capability to measure air pollution levels (PM2.5, CO2), UV radiation, and soil moisture can make the system more versatile for agricultural and urban applications
2) Scalability for Larger Regions – Expanding the system to multiple geographic locations can improve weather prediction accuracy and enable region-wide environmental monitoring.
3) Smart City & Agricultural Automation – The system can be integrated with IoT-based automated mechanisms, such as Adjusting traffic signals, irrigation systems, etc.
4) Smoke Detection Using CO_2 Monitoring– By analysing CO_2 levels, the system can help detect potential fire hazards in the environment. A sudden increase in CO_2 concentration along with temperature spikes can indicate fire outbreaks, allowing for early warnings and prevention measures.
5) Air Quality Index (AQI) Monitoring– The system can monitor and evaluate air quality levels based on real-time AQI measurements. By integrating AQI forecasting, it can help users understand pollution trends and take necessary precautions for health and environmental safety.

REFERENCES

[1] Ehigiator, E., & Sitti, M. (2024). An IoT-based weather monitoring system designed for cost- effective real-time data collection, storage, and predictive analysis. European Journal of Computer Science and Information Technology, 12(1),4356. https://doi.org/10.37745/ejcsit.2024.0122

[2] Huang, Z.-Q., Chen, Y.-C., and Wen, C.-Y. (2020) proposed a novel approach to real-time weather monitoring and prediction by integrating sensors and machine learning algorithms into city buses. Their study, published in Sensors (Volume 20, Issue 18, p. 5173), demonstrates how public transportation systems can be utilized for environmental data collection and urban weather forecasting.

[3] Mahala, A., Jayasingh, S. K., and Kabat, M. R. (2022) developed a weather monitoring and prediction system, with a specific focus on the Odisha region. Their research, included in Emerging Trends in Computer Science and Engineering (Chapter 40, pp. 509-523), highlights the use of advanced computational methods to improve weather forecasting in localized areas.

[4] Girija, C., Shires, A. G., Harshalatha, H., & Pushpalatha, H. P. (2018). A weather monitoring system based on the Internet of Things (IoT). International Journal of Engineering Research & Technology (IJERT), 6(13), 1-4.

[5] Rahut, Y., Afreen, R., & Kamini, D. (2023). A keen IoT-based framework for climate observing and real-time alarms. Worldwide Diary of Imaginative Investigate Considerations (IJCRT), 12(2), e876-e885. https://doi.org/10.5120/ijcrt2402571

[6] Tiwari, M., Narang, D., Goel, P., Gadhwal, A., Gupta, A., & Chawla, A. (2023). A climate observing framework utilizing IoT and cloud computing innovations. Worldwide Diary of Developments in Building and Science, 8(7), 23-26.