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WiFi Weather Station Prediction using ML

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***Abstract*—** Weather plays a crucial role in shaping our daily lives by providing insights into upcoming rain or sunshine. The process employed by meteorologists to anticipate weather conditions is termed weather forecasting. Climatic state parameters are determined by various factors, including temperature, pressure, humidity, dewpoint, precipitation, wind speed, and dataset size. In this experimental analysis we have develop a weather forecast prediction system using machine learning. This model uses Ridge regression algorithm to predict weather events such as temperature, humidity, rain and atmospheric pressure. Weather forecasting is the skill of predicting future weather patterns based on historical parameters such as temperature, humidity, wind direction and speed, precipitation, air haze, solar and terrestrial radiation, among others. The accuracy of weather predictions is contingent on the data collected, and the Linear Regression algorithm serves as the intellectual core of this process. As the number of considered parameters increases, the forecasting accuracy improves, enabling individuals to access tomorrow's weather forecasts. The data must undergo precise classification for effective prediction. To forecast unknowns, a thorough examination of directly or indirectly relevant variables is essential.

Keywords: *dewpoint, precipitation, regression, ridge.*

INTRODUCTION

A sophisticated weather monitoring system is assigned the critical task of identifying and collecting a diverse array of meteorological parameters from various locations, catering to the ever-growing demand for comprehensive weather analysis and accurate forecasting. In the pursuit of this objective, the integration of cutting-edge Cloud and Internet of Things (IoT) technologies stands out as a pivotal strategy.

At the core of this technological synergy lies the fundamental concept of the Internet of Things, a paradigm that revolves around interconnecting devices to the vast expanse of the internet and, by extension, to other essential devices. The transformative power of this concept manifests in its ability to facilitate seamless data transmission between IoT devices and the cloud, creating a dynamic flow that ultimately culminates in the delivery of pertinent information to end users. In the realm of weather monitoring, the Internet of Things emerges as a game-changer, providing a robust framework for the acquisition and utilization of critical meteorological data. Parameters such as humidity, temperature, pressure, and rainfall are not merely sensed and recorded; they become integral components of a data ecosystem, poised for both long-term analysis and real-time alert notifications. In the specific context of this project, a constellation of devices takes center stage, each contributing to the seamless gathering, organization, and presentation of collected weather data.

The Internet of Things, with its unparalleled potential, has the capacity to revolutionize environmental monitoring. This revolution is realized through the deployment of advanced sensors and devices equipped not only to record but also to process and transmit a plethora of weather parameters. The journey of the collected data extends beyond the physical confines of the monitoring devices. It embarks on a digital odyssey, finding its way to the cloud for further visualization and analysis. The intricate web of components within the system includes a versatile ESP8266 nodemcu, serving as the primary controller endowed with WiFi capability. This controller orchestrates the harmonious collaboration of other essential elements, including a solar panel, a USB connection, and a formidable 3.7V 18650 Li-ion battery that powers the entire circuit. The energy ecosystem within the setup is fortified by the inclusion of a TP4056 Li-ion charger module, meticulously connected to the solar panel. This module takes on the crucial responsibility of charging the lithium battery, ensuring a sustainable and uninterrupted power supply to the intricate network of components. As the IoT-driven weather monitoring system continues to evolve, it epitomizes the fusion of innovation and functionality, heralding a new era in environmental data acquisition and analysis.

LITERATURE REVIEW

[1] Zigbee based weather monitoring system

Throughout history, sensing winds and weather has been crucial, evident in structures like Athens' Tower of the Winds. This ancient tower, dedicated to the gods of the winds, still stands in Athens' marketplace. Contemporary weather impacts various aspects of modern life, including agriculture and transportation. Advanced weather monitoring systems track these changes cost-effectively, displaying parameters such as temperature, humidity, wind speed, and forecasts on LCD screens. Zigbee-based agriculture monitoring systems offer efficient environmental parameter tracking, reducing human effort and enabling cost-effective, low-power wireless monitoring, fostering innovations in Home and Health Care Automation. Recognizing the collaborative efforts of numerous sources is essential in such comprehensive projects.

[2] The Real Time Hardware Design to Automatically Monitor and Control Light and Temperature

The proposed temperature and lighting monitoring and control system offers users the ability to set specific environmental requirements. Crucial for industrial and experimental setups, the project continuously monitors and controls temperature and light through embedded systems. Employing microcontrollers enhances efficiency in industrial and research applications. This system, consisting of two modules - "Parameters Monitoring" and "Parameters Controlling," utilizes sensors for atmospheric data, connected to ADC and a microcontroller. It effectively maintains temperature and light levels, displaying values on an LCD screen, and allows user-set thresholds for control actions. The system, equipped with relays for temperature control and lighting devices, proves efficient, accurate, and energy-conserving.

[3] Low cost IoT based Weather station for Real Time Monitoring

This paper presents a cost-effective IoT-based water station designed to deliver real-time critical water information, including wind speeds, wind direction, temperature, humidity, and rainfall levels. The utilization of budget-friendly yet dependable controllers, specifically Node MCU and Arduino UNO, enhances accessibility for a broad spectrum of users. To ensure global access for authorized individuals, the data is hosted on a ThingSpeak web server. Wind speed is measured using a 3-cup anemometer, while a wind vane determines wind direction. The DHT22 digital temperature and humidity sensor is employed for temperature and humidity readings. Additionally, a custom acrylic glass rain gauge facilitates precise rainfall measurement. Through a dedicated circuit, all weather data undergoes debouncing before being directly uploaded to the ThingSpeak server. This innovative design addresses the issue of limited weather information availability across diverse locations. The emphasis on cost-effectiveness, coupled with the assurance of reliable and accurate measurements, promotes the adoption of this design in various research and educational institutions.

[4] Weather monitoring Station with Remote Radio Frequency Wireless Communications

The proposed temperature and lighting monitoring and control system serves as an integrated device for user-defined environmental requirements. Essential for industrial and experimental setups, it continuously monitors and controls temperature and light, employing embedded systems with microcontrollers, proving effective in both industrial and research applications. The project comprises two modules: "Parameters Monitoring" and "Parameters Controlling." Sensors acquire atmospheric data, connected to ADC and a microcontroller, with temperature and light sensors utilized. The system, equipped with four relays for temperature control and lighting, displays values on an LCD screen, initiating control actions as set thresholds are reached. This automated process effectively maintains temperature and light levels, contributing to energy conservation. The system's adaptability, cost-effectiveness, on-device display, and portability distinguish it from similar systems.

[5] Application of Soft Computer models for predicting sea surface temperature

Over the past five decades, the study of sea surface temperature (SST) has played a crucial role in understanding thermal exchanges, aquatic species behavior, and ocean currents. SST anomalies, deviations from average conditions, have been actively researched, impacting salinity, precipitation, and El Niño Southern Oscillation (ENSO) phenomena. Traditional methods like linear regression and statistical models, including Autoregressive Integrated Moving Average (ARIMA), relied on buoys and satellites. Recently, SC models, particularly those incorporating deep learning like LSTM and CNN, have gained prominence, offering improved accuracy and addressing challenges posed by complex SST anomalies. Future directions involve exploring alternative input variables, optimizing variable numbers, assessing machine learning models, and considering additional climate indices and regions for SST prediction. The integration of SC models in addressing specific environmental impacts, such as coral reefs and changes in ice thickness, represents an avenue for further exploration.

[6] Machine Learning for Weather Prediction and Forecasting for Local Weather Station using IoT.

The project aims to develop an IoT-based smart system for monitoring weather and predicting future values. This system is unique in its ability to monitor specific local areas, contributing to a microclimate system. It uses a monitored database to forecast future weather conditions for a specific zone, enhancing accuracy and relevance. The system is portable and has broad applications, surpassing existing websites that provide general weather information. It is suitable for various settings, including corporate offices, hospitals, and educational premises. The system uses a machine learning model, specifically the Autoregressive Integrated Moving Average (ARIMA) algorithm, to process the data and predict future values for various weather parameters. This system offers specific, tailored forecasts, marking a significant advancement in weather monitoring technology.

[7] Artificial Neural Network Model in Prediction of Meteorological Parameters during Premonsoon Thunderstorms

Thunderstorms, marked by intense convective activity, stand as captivating yet potentially damaging atmospheric events. These storms, synonymous with lightning and hail, possess global occurrence, posing threats to life and property. Particularly prevalent in the pre-monsoon period over India, severe thunderstorms bring destructive elements like lightning, squall lines, and torrential rain. Despite their brief duration, the socio-economic impact in eastern India is substantial. Accurate forecasting remains challenging; however, Artificial Neural Networks (ANNs), especially with the Levenberg-Marquardt algorithm, showcase promise in predicting thunderstorm-related meteorological parameters, offering valuable insights for timely warnings.

METHODOLGY

The sensor circuit, the esp8266 circuit, or the data logging circuit, and the cloud comprise the three primary components of the system. The temperature, humidity, and rain sensors make up the sensor circuit. An ADC transforms the analogue outputs from these sensors into digital signals, which are then supplied into the microcontroller-based data-logging circuit. After that, thinkSpeak displays the sensor data that was sent to the cloud via the nodemcu and wifi.

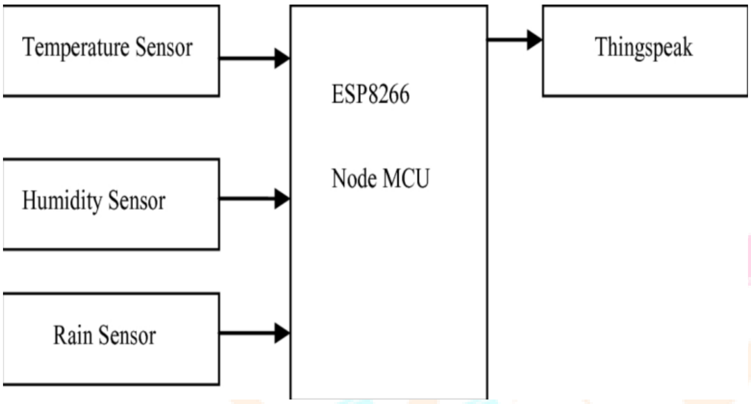

Fig-1: The working flow of the model

The popular and adaptable ESP8266 Wi-Fi module combines an integrated Wi-Fi microcontroller with extra features. Its purpose is to offer a cost-effective and efficient means of integrating wireless communication into a range of electronic devices. One microcontroller that can function both independently and as a slave device in tandem with another microcontroller is the ESP8266.
The pressure, rain, and humidity sensors will all be interfaced with the NodeMCU ESP8266 Wifi Module. We will send data to the thingSpeak cloud derived from temperature, pressure, humidity, and rainfall measurements. New keys can always be generated. Since we are only sending data from the Nodemcu ESP8266 to the ThingSpeak at this time, we will only be using the Write API key and the Channel ID.

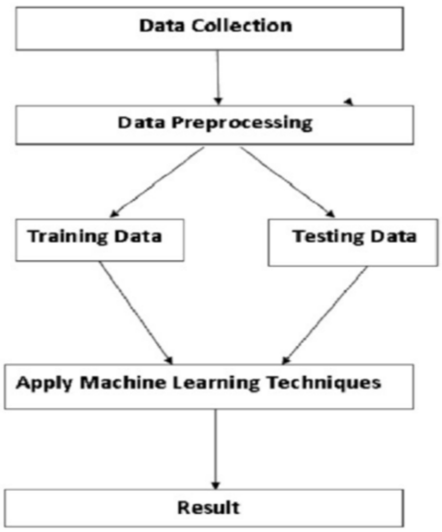

Fig-2: The functioning of the modification

Weather Data: Gathering weather data from a variety of sources, including satellites, weather stations, and other sensors, is the first step in the process. Temperature, humidity, wind speed, atmospheric pressure, and other variables are all included in this data.
Preprocessing: The gathered meteorological data is cleaned, filtered, and normalized as part of the preprocessing process. This stage guarantees that the data is reliable, consistent, and prepared for additional examination.
Training ML Models and Training Data: Training and testing sets of data are created from the preprocessed and feature-extracted data. The ML model is trained using the training data. Different ML algorithms can be used. The training data's relationships and patterns teach the machine learning model new things.

Evaluation of the Model: The accuracy and performance of the trained machine learning model are assessed by utilizing the testing data. Evaluation metrics that quantify the predictive power of the model, like mean absolute error or root mean square error, are frequently employed.

Real-time Prediction: The machine learning model is prepared for real-time prediction after it has been trained and assessed. The trained model is fed real-time meteorological data, which includes the state of the atmosphere at that moment. For the intended forecast horizon, the model generates weather predictions by applying the learned patterns and relationships.
Model Updating and Maintenance: To take into consideration shifting data trends, technological developments, and changing weather phenomena, weather prediction models must be updated on a regular basis. The performance and dependability of the ML model are maintained through constant observation, retraining, and modification.

RESULTS AND DISCUSSION

Analyzing the results of weather prediction using machine learning (ML) involves assessing the accuracy, reliability, and effectiveness of the ML-based models in predicting weather conditions. The fig below depicts the parameters and its success result:

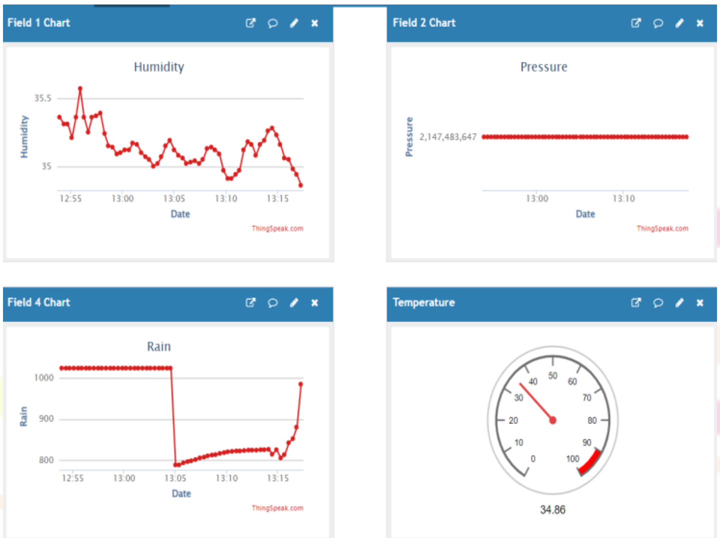

Fig 3: Result of recorded parameters

The NodeMCU would process the sensed data and forward it to the cloud platform ThingSpeak.com The results displayed in Figure 3 are simple dashboards designed to give a clear understanding of the significant parameters. We used ThingSpeak API to transfer the data to the cloud. The four parameters that will be displayed are pressure, humidity, temperature, and rain. The suggested solar-powered weather monitoring gadget is dependable for effective weather condition monitoring. Physically laborious tasks are reduced with wireless monitoring. When compared to a wired system, it is less expensive. Error is decreased by the accuracy and dependability of the digital sensors. The eco-friendly system is powered by a renewable energy source.

```
In [42]: predictions
Out[42]:
```

created_at	actual	prediction	diff
2023-04-05 10:34:30+00:00	32.3	32.211811	0.088189
2023-04-05 10:34:55+00:00	32.3	32.209646	0.090354
2023-04-05 10:35:19+00:00	32.3	32.207423	0.092577
2023-04-05 10:35:44+00:00	32.3	32.205148	0.094852
2023-04-05 10:36:09+00:00	32.3	32.205978	0.094022
...	...	...	...
2023-04-10 10:37:36+00:00	33.8	33.608270	0.191730
2023-04-10 10:38:01+00:00	33.8	33.595175	0.204825
2023-04-10 10:38:27+00:00	33.3	33.630716	0.330716
2023-04-17 11:07:42+00:00	33.3	33.340652	0.040652
2023-04-17 11:08:07+00:00	33.3	33.393391	0.093391

123 rows × 3 columns

Fig 4: Result of predicted temperature

If observed through nearsightedness, it might be discovered that this system still needs a great deal of improvement. For instance, we can use a variety of sensors to update our learning mode. Overall, a thorough grasp of the effectiveness, constraints, and promise of ML models in precisely forecasting weather conditions should be provided by the result analysis and talks on weather prediction using ML. It should also outline the advantages and practical applications of machine learning-based weather forecasts across a range of industries and recommend directions for future study and development.

CONCLUSION

This paper introduces a technology for delivering weather forecasts through the application of machine learning techniques. The evaluation results demonstrate the accuracy of these machine learning models, establishing their competitiveness with traditional models in predicting weather features. Additionally, we enhance the forecasting effectiveness by incorporating historical data from

neighboring areas when predicting the weather for a specific location, as opposed to considering only the target area. For future implementations, we plan to leverage cost-effective Internet of Things (IoT) devices to collect meteorological data from diverse locations within a city, encompassing pressure, temperature, humidity, and rain sensors. The inclusion of multiple sensors may introduce more local features into the training dataset, further enhancing the predictive capabilities of our models. The utilization of both this additional data and weather station data is anticipated to optimize the performance of our prediction models.
The future scope of the WIFI Weather Station Prediction using Machine Learning is expansive, paving the way for advancements and applications across various domains. Research opportunities abound in the integration of additional parameters, such as air quality, UV index, and cloud cover, to augment the model's predictive capabilities. This exploration aims to broaden the spectrum of climatic variables, promising more comprehensive and accurate weather predictions.

A significant avenue for improvement lies in the potential for real-time data streaming, enabling continuous updates and immediate adjustments to weather predictions. The system's enhancement could involve seamless integration with advanced sensors and IoT technologies, facilitating up-to-the-minute data transmission. Collaborative efforts could lead to the establishment of a global network of WIFI Weather Stations employing similar machine learning models. Such a network has the potential to create a comprehensive, interconnected system, providing accurate and localized weather predictions on a global scale. The development of user-friendly interfaces and mobile applications stands out as a crucial aspect, making weather predictions more accessible to the general public. These applications could incorporate personalized alerts, historical data visualization, and interactive features to cater to diverse user needs.
Expanding the system's scope to assess the impact of climate change by analyzing long-term trends and patterns is another avenue for future exploration. This aspect of the research could contribute valuable insights for understanding and mitigating the effects of climate change. Tailoring the machine learning model to cater to the specific needs of industries like agriculture, aviation, and tourism offers a strategic direction. Providing specialized weather predictions can assist these sectors in making informed decisions and optimizing their operations. In essence, the WIFI Weather Station Prediction system serves as the foundation for a dynamic and evolving field. It presents ongoing opportunities for research and innovation in the realms of weather forecasting and climatic analysis, promising a future characterized by enhanced accuracy, accessibility, and adaptability in predicting and understanding weather patterns.

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