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A futuristic digital interface with a glowing Earth globe in the center. The background is dark blue with various data visualizations including bar charts, line graphs, and network diagrams. Text elements like 'BUSINESS', 'NETWORK SEARCH', and 'LADING 100%' are visible. The overall aesthetic is high-tech and data-driven.

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Temperature and Humidity Prediction Using IoT and Machine Learning

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ABSTRACT: Predicting the weather, specifically temperature and humidity, has become smarter and more accurate with the help of the Internet of Things (IoT) and machine learning. In this paper, we discuss a new system that can make reliable predictions about temperature and humidity using integrated IoT sensors, specifically the DHT11 for capturing temperature and humidity readings, the MQ135 for detecting gases, and the NodeMCU as a microcontroller for data transmission. These sensors feed their data into AWS IoT for storage and further processing. Machine learning models, namely Decision Tree, Random Forest, Linear Regression, and LSTM (Long Short-Term Memory), are employed to process this data, aiming to accurately predict future temperature and humidity readings.

KEYWORDS: IoT (Internet of Things), Machine Learning, DHT11, MQ135, NodeMCU, AWS IoT, Decision Tree, Random Forest, Linear Regression, LSTM (Long Short-Term Memory)

I. INTRODUCTION

In today's data-focused world, our project aims to bring a new and easy way to keep an eye on the environment using IoT and machine learning. We are using a simple gadget that comes with NodeMCU ESP8266, DHT11, and MQ-135 sensors to regularly track temperature and humidity levels. This gadget sends all the information it collects to the AWS IoT platform, making it easy to store and manage the data. To make things even more user-friendly, we've created a webpage where anyone can watch these environmental conditions change in real-time, thanks to WebSocket technology. On the back end, we use straightforward but powerful tools like Decision Tree, Random Forest, Linear Regression, and LSTM to accurately guess what the future temperature and humidity levels might be. This project represents a simple yet smart way to keep track of and protect our environment. In simpler terms, our project is like a weather forecaster in your pocket, offering you live updates and helping predict what the environmental conditions might be like in the near future. It's a straightforward, yet powerful tool that makes environmental monitoring accessible and understandable for everyone, encouraging a broader community involvement in safeguarding our surroundings.

II. PROBLEM STATEMENT

Traditional approaches to temperature and humidity monitoring fall short in delivering real-time, accurate predictions. As the need for exact environmental data has surged across different sectors, these shortcomings have become more apparent. The existing systems for temperature and humidity monitoring often rely on sporadic data collection, resulting in incomplete and outdated information. This lack of real-time insights compromises the ability to respond swiftly to changing conditions, potentially leading to suboptimal resource allocation and missed opportunities. Moreover, the simplistic nature of conventional predictive models used in these systems undermines their accuracy. These models fail to capture the complex relationships between environmental variables, causing predictions to deviate from actual conditions. As a result, stakeholders are confronted with unreliable forecasts that hinder their capacity to make informed decisions.



III. RELATED WORK

In [1], A. Vamseekrishna and team presented "Prediction of Temperature and Humidity Using IoT and Machine Learning Algorithm". The study undertook an exploration into temperature and humidity prediction using IoT coupled with the linear regression technique in machine learning. By leveraging the Message Queuing Telemetry Transport (MQTT) protocol, they gathered climatic data from diverse locations over a span of several days. This amassed data was then processed in the Amazon Web Services (AWS) ecosystem and, with the aid of Dynamo Database (DynamoDB), was structured into tabular forms and subsequently saved as .csv files. They then harnessed the linear regression algorithm for predicting temperature and humidity patterns.

In [2], Shubham Madan delves into "Analysis of Weather Prediction using Machine Learning & Big Data". Madan's study focuses on forecasting weather patterns through the synergistic application of big data techniques and machine learning. The forecast was based on parameters such as peak and trough temperatures, average humidity, and atmospheric pressure. Linear regression and support vector machines were the primary algorithms utilized. The accuracy of the project was determined via the 'root mean squared' evaluation method.

In [3], Munmun Biswas, along with Tanni and Sayantanu Barua, in their 2018 publication "Weather Forecast Prediction: An Integrated Approach for Analyzing and Measuring Weather Data", propose a novel approach for predicting weather using machine learning. They employed algorithms like 'Chi_square' for forecasting and 'Naïve-Bayes' for classification. Data attributes, including 'outlook, temperature, humidity, wind', were utilized to discern weather as 'Good' or 'Bad'. Their findings suggest that this approach can effectively identify the underlying nonlinear relationships within historical climate data and offer future weather predictions.

In [4], Aris Pujud Kurniawan and colleagues, in their 2017 research titled "Weather Prediction Based on Fuzzy Logic Algorithm for Supporting General Farming Automation System", developed a weather forecasting mechanism using fuzzy logic. This was tailored to assist automation in agriculture. They sourced data from weather service platforms and subterranean sensors. Integrating rain and soil moisture sensors, the fuzzy logicbased system determined irrigation requirements for crops. The effectiveness of their system was gauged through daily plant observation, registering a 100% accuracy rate over eighteen days across 33 test instances.

In [5], Mark Holmstrom, Dylan Liu, and Christopher Vo, in their 2017 work "Machine Learning Applied to Weather Forecasting", constructed a weather forecasting framework. They employed both 'linear regression' and 'functional regression' techniques to delineate factors influencing weather patterns. They implemented '4-fold forward chaining time-series cross-validation' to validate their model's precision. Upon comparing their system with established 'professional weather forecasting services', they observed an initial performance lag. However, over time, the error margin in their predictions showed notable reductions.

IV. PROPOSED SYSTEM

To address the limitations of the existing systems and unlock the full potential of temperature and humidity monitoring, this project presents a holistic and innovative solution. The proposed system leverages the capabilities of IoT devices, machine learning models, and dynamic interfaces to provide accurate predictions and real-time insights. The proposed system lies in the utilization of IoT devices, specifically the esp8266, DHT11, and MQ-135 sensors. These devices collectively form a network that continuously collects real-time temperature and humidity data from the environment. This dynamic data stream serves as the foundation upon which accurate predictions will be built. Machine learning techniques are fundamental to the system in discussion. Through regression strategies and LSTM-based time series predictions, the initiative seeks to craft models adept at examining past data trends and projecting them forward. One of the distinctive features of the proposed system is its emphasis on user-friendly interfaces. Real-time monitoring web pages provide stakeholders with immediate insights into changing environmental conditions, allowing them to respond proactively. Predictive monitoring web pages extend this functionality by offering forecasts that guide future actions.

Advantages of Proposed System

1. Real-time Data Collection and Monitoring: The integration of IoT devices enables realtime data collection, offering a continuous stream of accurate temperature and humidity readings.
2. Enhanced Forecasts via Machine Learning: Utilizing sophisticated machine learning models, such as regression and LSTM-based time series forecasting, boosts the precision of temperature and humidity estimations.
3. Adaptability to Changing Conditions: The proposed system is designed to adapt seamlessly to dynamic environmental conditions. As temperature and humidity fluctuations occur, the system's real-time data collection and predictive models adjust accordingly, ensuring that stakeholders receive relevant and actionable insights.
4. Enhanced User Interfaces for Decision-Making: Real-time monitoring interfaces offer immediate visualizations of changing conditions, aiding proactive responses. Predictive monitoring interfaces provide stakeholders with a glimpse into the future, enabling strategic planning and resource allocation.

V. METHODOLOGY

In this system, we aim to develop an IoT-based environmental monitoring system integrating DHT11 and MQ135 sensors with a NodeMCU microcontroller for real-time data collection of temperature, humidity, and gas levels. This data is transmitted to AWS IoT for centralized storage, before being extracted, converted to .csv format, and refined for analysis. Various machine learning models including Decision Tree, Random Forest, Linear Regression, and LSTM are then selected and trained to discern patterns within the data, with performance fine-tuned using a validation set. Simultaneously, a real-time monitoring system is established, utilizing the trained models to make predictions based on the incoming sensor data, and displaying temperature and humidity predictions instantaneously. An anomaly detection algorithm is also integrated, flagging any irregular patterns or significant environmental shifts. Finally, a web application is developed using the Flask framework to facilitate the real-time display and visualization of prediction results in a user-friendly format, offering a comprehensive solution for real-time environmental monitoring and analysis.

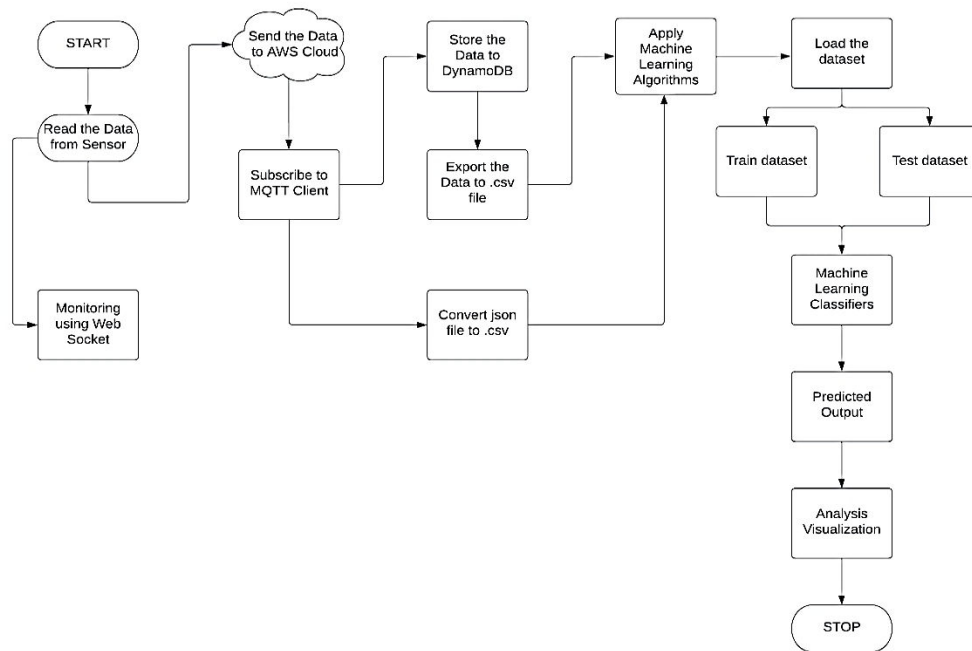


Fig 1 : Flow of the System



Machine Learning Implementation

In the implementation phase of our project, we first establish several different models to analyze and predict temperature and humidity levels based on the data collected from our IoT device. Initially, we set up four different types of models - Decision Tree, Random Forest, Linear Regression, and LSTM. The Decision Tree and Random Forest models are trained using fit method with the training data set (X_train and y_train), and then predictions are made both on the training set and test set to evaluate their performance. Similarly, a Linear Regression model is initiated and trained using the same method to predict outcomes based on linear relationships between variables. Alongside these, an LSTM (Long Short-Term Memory) model is created as a part of a sequential neural network, designed to work with time series data, which can remember patterns over long sequences. This model is particularly configured with 50 units and expects input data to have a specific shape that corresponds to the structure of our training data. It employs 'adam' as the optimizer and uses 'mean_squared_error' as the loss function to train the network over 50 epochs, in batches of 10, using a subset of the data for validation during training. After the models are trained, predictions made are then inverse transformed to convert them back to the original scale for a coherent analysis and comparison of the predictions with the actual values. This multi-faceted approach ensures a comprehensive analysis of the data, allowing us to make accurate predictions regarding future temperature and humidity trends.

VI. EXPERIMENTAL RESULTS

After implementing Decision Tree, Random Forest, Linear Regression and LSTM models to Predictive model and also with the Real-Time Monitoring, we, got the following results:

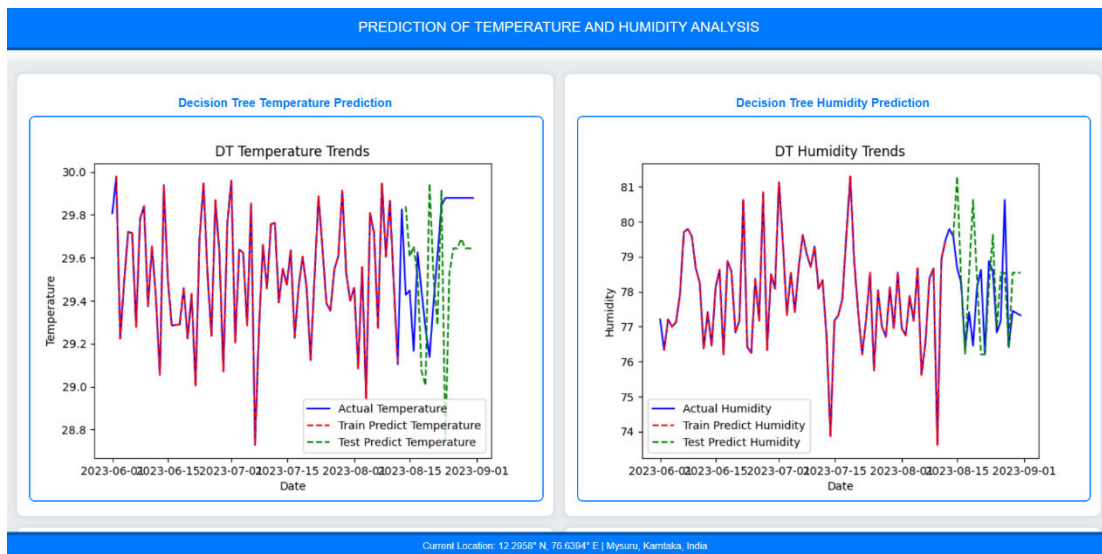


Fig 2: Decision Tree Prediction Result

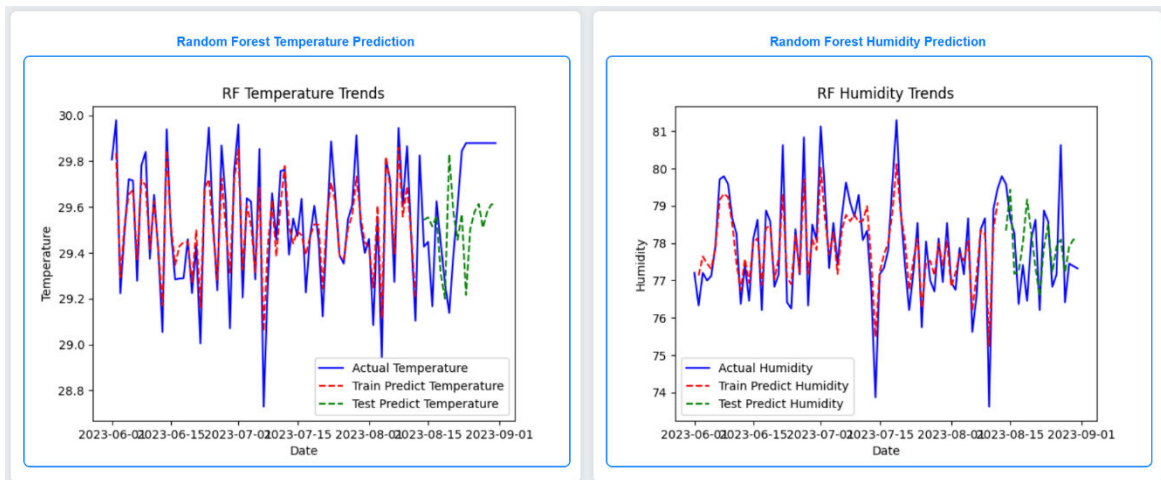


Fig 3: Random Forest Prediction Result

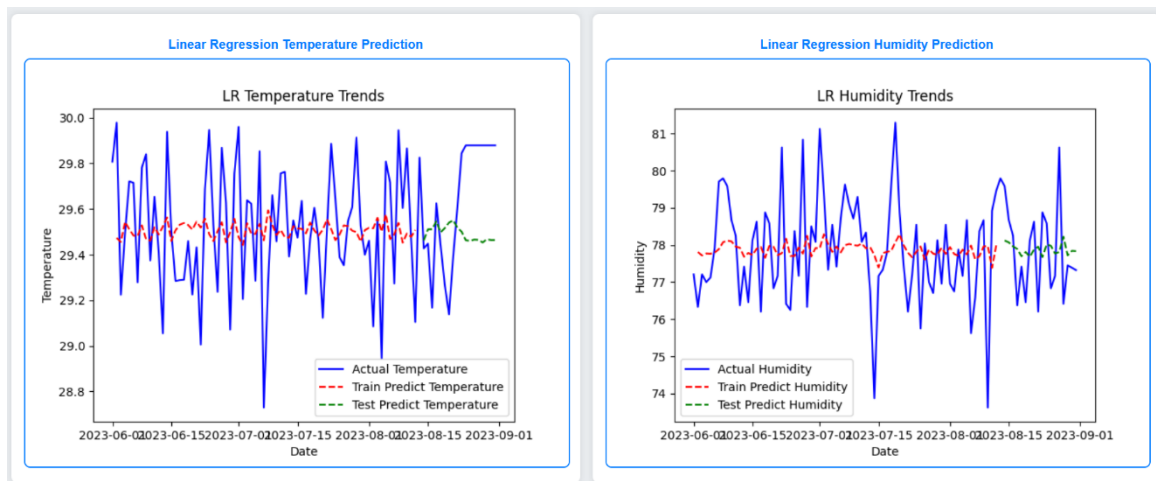


Fig 4: Linear Regression Prediction Result

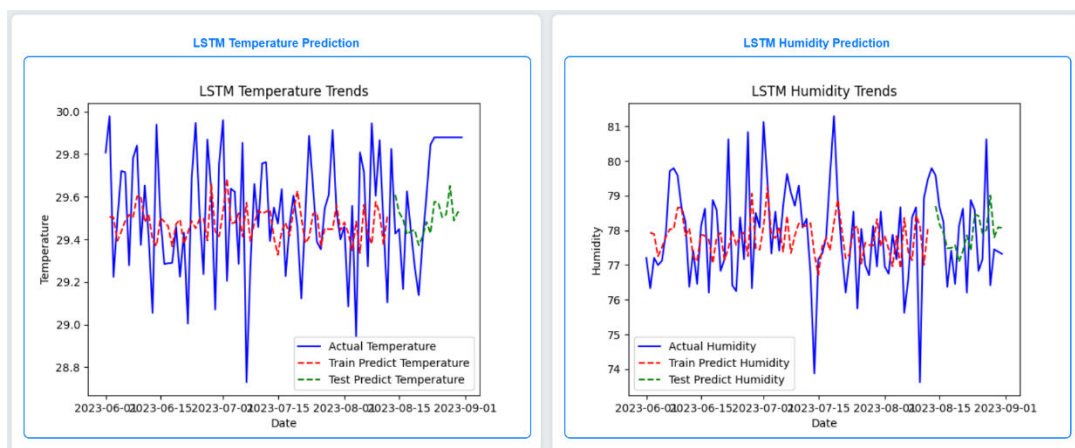


Fig 5: LSTM Prediction Result

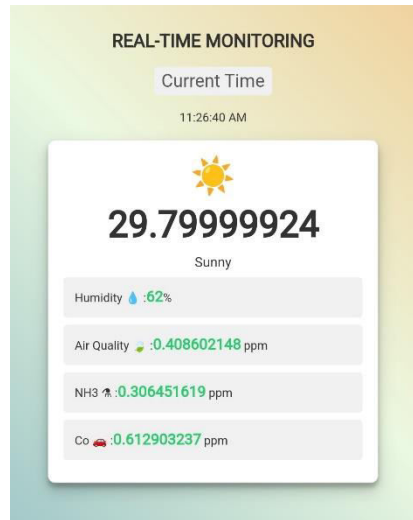


Fig 6: Real-Time Monitoring Result

Prediction Analysis Result:

This side-by-side comparison serves as a graphical testament to the model's accuracy, precision, and reliability. These comparative visuals, often manifested in line graphs or scatter plots, help in understanding the extent to which our predictive models align with real-world data. Distinct lines or markers representing the "actual" and "predicted" data were visible, and any divergence between these two lines gave an immediate visual cue about areas where the model's predictions were off the mark.

VII. CONCLUSION

The integration of the Internet of Things (IoT) with machine learning has opened up transformative opportunities across various domains. In the context of our major project, it enabled us to make informed predictions about temperature and humidity, showcasing the potential and effectiveness of these combined technologies. IoT devices have become indispensable in today's fast-paced world, providing real-time data with unprecedented accuracy. By leveraging sensors that capture ambient conditions, we collected vast amounts of data related to temperature and humidity. These continuous streams of data, while valuable on their own, become transformative when interpreted and analyzed using machine learning algorithms. Machine learning, in essence, enabled us to glean insights from this raw data. By training our models using historical temperature and humidity data, we could predict future conditions with remarkable accuracy. Not only did this prediction process enhance the utility of the data we collected, but it also provided actionable insights. For instance, predicting a sudden spike in humidity could help agriculture experts adjust irrigation, or anticipate the spread of certain humidity-borne diseases.

FUTURE ENHANCEMENT:

To enhancing this system, we consider several upgrades that can augment its accuracy and utility. Firstly, we can broaden the spectrum of data sources, incorporating information from satellites, local weather stations, and crowd-sourced platforms, which can potentially offer a richer and more comprehensive view of environmental patterns. Secondly, there's room to explore more advanced machine learning algorithms, venturing into the realms of deep learning, which promises to discern complex patterns in large datasets, thereby refining our predictions further. Moreover, adapting our system to conduct real-time predictive analysis could be a pivotal advancement, offering



immediate insights that can facilitate swift actions in crucial sectors such as agriculture or healthcare. This shift from daily or hourly predictions to instantaneous analyses would be a game-changer. Additionally, integrating other significant environmental parameters, such as wind speed, air pressure, and pollutant levels, would enable our system to furnish a more holistic view of the environmental conditions, thereby enhancing the overall value and reliability of our predictions. To make these sophisticated predictions accessible and beneficial to a broader audience, we envision developing a user-friendly interface, possibly a dashboard or a mobile application. This platform would cater to individuals with no technical background, providing them with alerts, visually appealing data representations, and potentially, recommendations based on the forecasted conditions, thus bringing the power of data-driven environmental insights to the fingertips of the common man.

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