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Systematic Review of Environmental Temperature Prediction using IoT-based Machine Learning Technique for Agriculture

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Abstract: To forecast the dependent variables, which include temperatures, a variety of factors must be considered. These criteria are dynamic and fluctuate over time with the atmosphere. An accurate prediction of greenhouse temperatures is critical to practical greenhouse farming. Think to speak, and technology is a rapidly evolving field that aims to integrate "matters" people and machines onto the internet. Global industrial and computer stations threaten to degrade the environment because of their inherent destructive potential seriously. Choosing the best air is a need of the highest order. Because of the alarming statistics on greenhouse gas emissions, there has been an increasing worry about the need to improve the energy efficiency of the construction sector throughout the world. It is widely accepted that building energy systems management is an essential part of the process. The ability to precisely predict the temperature within a structure is a crucial component of these systems management techniques.

Regarding affecting people's quality of life, temperature and humidity are the most evident environmental indicators that can be discovered in a home—household activities to increase the general degree of intellect. Because of the increasing research on the Internet of Things and Machine Learning, many distinct models for predicting temperature have evolved. The difficulty in precisely forecasting the weather persists, despite these efforts. IoT-related and machine learning techniques such as Decision Tree and Time Series Analysis; Linear Regression; Multi-Rational Tree; SVR; etc.; and a deep learning model have been used in this current work. To reduce the global temperature, methods now in use might benefit the whole world since humans and a broad range of other species are impacted

Index Terms **- Temperature Prediction, IoT, Machine Learning, Decision Tree and Time Series Analysis, Linear Regression, Multi-Regression tree, Support Vector Regression.**

Introduction

Modern technology can meet fundamental human needs. The Internet of Things (IoT) can impact people's perceptions and surroundings in the modern world. Most IoT applications in agriculture and the environment need ongoing monitoring [22]. These subjects are diverse. The Internet of Things might help farmers in the future. IoT may be utilized for environmental applications outside data collecting and cloud storage. Internet of Things sensors can feed data into predictive models for forecasting environmental variables, allowing suppliers, technicians, farmers, distributors, consumers, businesspeople, and government representatives to make quicker and more accurate decisions to create a safe and healthy environment for all living things. Traditional modelling cannot properly anticipate long-term multivariate data relationships. Complex modelling methodologies explain this. Many RNN or CNN-based deep learning models have been created. Improve forecast accuracy and reduce periodic data dependency on multivariate time series.

Climate change is one of humanity's biggest issues. Most climate scientists believe that global warming will harm the planet. Human activity causes biodiversity loss, soil erosion, dramatic temperature variations, increasing sea levels, and global warming. Health, the economy, food safety, and energy consumption are affected.

The weather is multifaceted, continuous, and dynamic, requiring a lot of data. Even if they're in the same place, the local climate may vary in temperature, humidity, and other ways. This effort gathers data from greenhouse sensors to predict the temperature and boost greenhouse farmers' productivity and effectiveness. Temperature, humidity, soil temperature and moisture, wind speed, and wind direction are key study characteristics. Agriculturalists must anticipate and adapt to weather changes to sustain natural resources. So, an IoT-based greenhouse temperature prediction system employed a multivariate convolutional LSM network.

Environmental temperature prediction predicts a region's temperature and atmosphere. This example shows how important accurate temperature predictions are for daily chores. Temperature forecasting is crucial for living and nonliving things. Even though temperature forecasting isn't new, India's sector is young and faces several challenges. Temperature forecast must handle nature's subjective and inappropriate expectations. "Automated temperature prediction" is a technique that monitors and records atmospheric characteristics without people [10]. Agriculture, businesses, and other organizations must investigate temperature

predictions. Technological advances have made understanding natural features simpler. Sensors measure physical and ecological variables. Instead of depending on sensor outputs, it may be more accurate and economical to use temperature sensors [9].

Global warming is a long-term increase in Earth's average climate system temperature. Chemical and physical mechanisms have contributed to this climatic transition, including CO2, N2O, CH4, and others. In weather, frequency and concomitance are increasing. This raises Earth's temperature. Since 1990, the temperature has increased due to contemporary industries, vehicles, and fossil fuel consumption. In a century, the planet's average temperature rose 1°C. Many experts expect the average global temperature to rise by 6 degrees Celsius over the next 200 years compared to present records when greenhouse gases absorb solar energy reflected from the earth's surface [1].

The average temperature will rise as the atmosphere warms. Killer global warming. Warming has hastened glacier retreat. Rising seas overwhelm coastlines. Found around shorelines. Decreased deep-earth water. The oceans are warming. Result: devastating storms. His acts raise the likelihood of atopic dermatitis, asthma, and skin diseases. Scientists warn that if global warming continues, many cities may drown. [21] mentions warming. We discuss global warming's implications and solutions. Read a paragraph for weather details known as [20]. Our technique helps us estimate rising global air temperatures. ANN-based models forecast monthly high and low temperatures in India's Chaliyar River Basin. "Atmospheric Temperature Prediction Using Support Vector Machines," "Big Data and Climate Change," "Atmospheric Temperature Prediction," "Artificial Neural Networks (The Multilayer Perception) - A study of atmospheric sciences," Using Optimal Neural Networks with Stochastic Factors to Predict Air Quality. [19] analyze and forecast temperature, air condition, and other characteristics. This research covers temperature, global warming, and related subjects [8]. Many individuals reduce fossil fuel consumption to combat global warming [14]. They're also raising awareness about cutting U.S. greenhouse gas emissions. Rising sea levels harm many cities and seaports. London, NY, VA, SYD, CHAR, Mumbai, etc. Global warming is causing woods to lose trees, says a new study. Unbalanced atmospheric gas concentrations exist worldwide. Small yet mighty. High temperatures hinder agricultural cultivation, harming animal food systems. No one sentence can summarize global warming's impacts.

I. Related Review

This section examines the most recent methods of temperature prediction that have been published in the scientific literature. The least complicated prediction model for the study is linear regression. A regression model's estimates are often used to illustrate the relationship between two variables and highlight how the two variables are related to one another. Linear regression may be used to find the best-fit line between the points on the graph. What's known as a regression line is a line that's most likely to fit all of the data points. It's up to the data to define the line's form, which might be either straight or curved. The best-fit line may also be a quadratic or polynomial, providing better answers to our problems. These algorithms include Decision Trees and Time Series. Temperature analysis and forecasting have been a major problem in the industry since its inception. Every day, new methods are developed to replace the ones that have become obsolete. Academic studies have proven that machine learning techniques perform better than traditional statistical methods. – There will be a new wave of computing that personal computers will no longer dominate. Internet of Things (IoT) refers to a new paradigm in which almost everything in our daily lives will somehow be linked to the internet. Machine learning and the internet of things go hand in hand.

Weather forecasting ideas and initiatives abound, whether it's temperature, precipitation, or a combination. Some of those ideas will be taken into account in this reference. This research predicts the temperature and greenhouse gas levels over the next several years. This is why most thoughts and activities related to weather forecasting are being prioritized. It's possible to estimate the total quantity of precipitation using concept number 9. Artificial Neural Networks (ANNs), Support Vector Regression (SVR), and other methods are used in this study. This theory only considers precipitation as a factor. It provides no data on temperature or greenhouse gas concentrations. Also, making predictions is at the heart of the idea [11]. This concept just takes into account the temperature. Climate change's physical drivers aren't getting the attention they deserve. These results were obtained using multi-layer perceptron and support vector regression (SVR). The number [4] represents another strategy based on foresight. Thanks to this research, it may be possible to predict how much rain would fall using regression analysis and a synthetic neural network. In this idea, the only thing that matters is the amount of rain. Neither the temperature nor the greenhouse gas emissions are considered [18]. There is also a reference to "[18]" throughout. All three metrics mentioned above come in handy while working on this project.

As an alternative, this theory focused only on precipitation rather than temperature or greenhouse gas emissions. In addition, the source [3] is cited. Artificial Neural Networks (ANNs) are used in this research to monitor and analyze rainfall data. Similarly, this theory does not explain the occurrence of global warming. There is also a reference to the number [17]. This project makes use of SVM, lasso, and random forest. An explanation of this notion is more nuanced and not clear. The concept has been centred on the topic of climate change. According to [7], this article also relies on the author's work referenced in [7]. The article's explanation is strong. However, the focus is on the weather as a whole rather than on a single component. In addition, the number [2] is mentioned in our research. In addition, the explanation is based on general meteorological conditions rather than conditions unique to a particular area. As a result, [15] does not focus only on the effects of global warming. Similarly, the paper in [12] relies on forecasts but does not focus on global warming or temperature changes.

When it comes to affecting people's quality of life, temperature and humidity levels are the most evident environmental indicators that can be discovered in a home. In this research, an indoor temperature and humidity prediction model based on the BP neural network is built to increase the intelligence level in everyday life. Predictions of interior temperature and humidity at a certain moment in the future may be made more accurately using a single-step forecast approach than a multi-step or rolling forecast. For the first 365 days of 2016, a household's temperature and humidity data is utilized for training a prediction algorithm. Temperature and humidity readings from the previous day are used to check the forecasts' accuracy. The results of MATLAB simulations show that the indoor temperature and humidity prediction model is accurate. [24]

While evaluating the development of the institutions, it is important to consider the average year-round temperature of the nation to evaluate whether or not this technique should be used. According to the List first website, the total university scores for the 2020 ranking for USHERS and AAT for the nations in which these institutions are located were acquired. We employed the linear regression approach to determine whether the AAT correlates with university rankings. According to the early results, a country's AAT does not affect how national universities are rated. An analysis of fit and residuals reveals that the model fails to explain a major portion of the residuals, while the latter shows no linear trend in the dependent variable. [25]

The temperature of the transformer's oil is frequently a limiting factor in the transformer's performance. Because the quantity of heat released by a transformer depends on the environment and the conditions in which it is positioned, this impacts the transformer's load capacity. The temperature distribution of a transformer is simulated and evaluated in this work using a computational fluid dynamics (CFD) model in a range of installation scenarios and external conditions. The simulation results provide a theoretical basis for optimizing heat dissipation, ventilation, and transformer layout to determine a transformer's load capacity in a given environment. [23]

Calculations and testing show that the sensor's temperature field shifts in response to changes in the ambient temperature. The thermistors' average temperature difference, given by T, will decrease as the temperature rises. The temperature coefficient of the average temperature, T, with the temperature change is 0.061K/°C. The average relative difference of the computed results from the actual value is 4.7 percent. At a certain angle, the thermistor resistance difference R and the unbalanced voltage of the check bridge output grow as the temperature differential T decreases. As the temperature drops, the temperature differential T becomes larger. Measurements have shown an increase in sensitivity of the sensor of 0.067% with each degree increase in temperature. Sensor sensitivity drift may be minimized using this work's theoretical and experimental foundations for temperature adjustment. [13]

Analyzing past temperature and carbon dioxide emissions data collected across India, this research investigates how the linear regression machine learning approach is presented. Climate research, agriculture, electricity, medicine, and many other fields might benefit greatly from long-term global warming and weather forecasts. The data are calculated and predicted using linear regression since it is the most accurate approach for global warming and temperature among the several methods. The first step is to develop a statistical data model that is repeatable, efficient, and dependable in all respects. A big data collection must be used in this model to discover the association between yearly average temperature and variables that contribute to global warming. The whole globe benefits from a temperature drop since global warming harm many living things and people. [26]

There is a prediction overhead of 0.22, 0.097, and 0.026 ms per prediction in the simplified Gaussian process model, the neural network model, and the Lasso linear regression model. Compared to the prior Gaussian process model's prediction overhead of 0.57 ms per prediction, these overheads are significantly reduced. A two-node system design has been used to test our proposed thermal prediction models to determine the optimal work allocation. Up to 11.9 degrees Celsius of temperature reduction may be achieved while retaining the same level of performance by placing jobs in an optimal position, according to the simulations. A further 75, 82.5, and 74.17% of these models can reliably indicate the job areas with the best thermal response. This is compared to the prior model's 72.5 percent success rate in reaching the same goal. For our last experiment, we trained models, implemented them in real-time, and achieved a 17 percent reduction in the overall cooling power needed by the system, significantly improving our first findings. [16]

Machine learning (ML) experts may ask what role they might play in tackling one of humanity's most pressing issues: global climate change. To help society cope with climate change, we'll explore how machine learning may help reduce greenhouse gas emissions and aid climate adaptation. For example, smart grids and disaster management are high-impact areas where machine learning and other fields of study may help fill in knowledge gaps. We've got ideas for both academic and business pursuits. Take a look at what we've come up with. To combat climate change, we are appealing to the machine learning community. [27]

Linear regression is used to calculate and forecast global warming and temperature since it provides the most accuracy. First, develop a consistent, effective, trustworthy statistical data model using a large data set to determine the link between average yearly temperature and global warming variables. Global warming affects not just humans but also animals; therefore, reducing it would benefit everyone [6].

Internet of Things (IoT) Technology IoTs have been used in a broad range of applications during the last several years. IoT-enabled agricultural technologies are rapidly being used to improve agricultural yields and quality while reducing costs in the industry. Farmers may benefit from precision agriculture, which allows them to make more educated decisions based on statistical data [5]. Precision farming is one of the uses of this technology. With the Internet of Things, sensors and actuators may be included in everyday objects by decreasing the hardware components and lowering the cost. In addition, one of its goals is to connect the different pieces of hardware to the internet through wired and wireless networks, to provide real-time information, and to preserve it for later processing. Many Internets of Things applications, such as smart agriculture and intelligent animal husbandry, have been created and tested in the agricultural sector. Soil moisture, temperature, and relative humidity may all be determined by farmers using the standard farming method. This strategy is tedious, time-consuming, and difficult to implement daily.

Table 1. A critical review of the latest paper 2019 to 2022

Reference	Authors name	Year of Publication	Title	Method	Result	Limitation
[23]	S. Hualin et al.	2019	Simulation Analysis of Temperature Distribution of Oil-immersed Self-cooled Transformer under Different Environmental Conditions	CFD model	Optimize transformer heat dissipation, ventilation, and architecture.	Their results were calculated based on simulation but didn't use any machine learning model
[24]	H. Tao et al.	2020	Predictive analysis of indoor temperature and humidity based on BP neural network single-step prediction method	BP neural network	The interior temperature and humidity model is accurate.	The author used the single-step prediction method

[25]	A. Buzaboon et al.	2021	Temperature-dependency of Environmental Higher Education Ranking Systems	Only Statical analysis	Initial findings reveal AAT doesn't affect a country's university ranking.	The dependent variable isn't linear.
[26]	M. Purushotham Reddy et al.	2021	Global Warming Analysis and Prediction Using Data Science	Linear Regression	Global warming affects not just humans but animals; reducing it would benefit everyone.	Calculate only annual temperature and contributing factors to global warming
[27]	D.R. et al.	2022	Tackling Climate Change with Machine Learning	LSTM	The result of helping agriculture	Apply deep learning for prediction

II. Environmental Temperature Prediction Using Machine Learning

An artificial intelligence area known as "machine learning" (ML) is referred to as such. The basic goal of algorithm development in this subject is to arrive at a mathematical model that matches the data. This model may be used to create predictions based on new data after it has adequately represented the old data. A model's estimation of unknown parameters relies on a specific data set, and the output prediction is made using the freshest available data and the parameters gathered during the previous step.

Although the dynamics of the system and its links are difficult to describe, ML techniques find models between inputs and outputs in this way. This enables the tactics to be successful. Various domains, including pattern recognition, categorization, and forecasting, have made substantial use of this method. Three of the most often utilized ML approaches are as follows:

Training sets are labelled based on knowledge about how the model will perform, which is used to train the model.

Without understanding the desired outcome to label training data, data are simply learnt without supervision in the form of unsupervised learning. Because of this, a clustering algorithm needs to look for patterns in the input data.

Without understanding the desired outcome to label training data, data are simply learnt without supervision in the form of unsupervised learning. Because of this, a clustering algorithm needs to look for patterns in the input data.

The best results are obtained using semi-supervised learning, which integrates labelled and unlabeled inputs.

A scalar reward or reinforcement signal is used to maximize the learning process in Reinforcement Learning. If the system's goal is positive or negative, this signal will be either way. They are referred to as "rewards" when they are good and "punishments" when they are bad.

Particular attention must be paid to the fact that, in this field, temperature and relative humidity readings, solar radiation, rain, and wind speed are among the most often utilized input parameters. Mean Absolute Percentage Error (MAPE), Mean Absolute Error (MAE), Median Absolute Error (MdAE), Root Mean Squared Error (RMSE), and Mean Squared Error (MSE) have all been used in these studies to assess the performance of these methods (MSE). They have been utilized more often in these studies to evaluate the performance of these algorithms (MSE).

III. Research Gap

The following is a description of the research gaps that may be revealed in this evaluation to continue studying this topic when these basic concerns are taken into account:

- Most of the research included in this review focuses on analyzing air temperature in different parts of the country. Despite this, detailed research has not been done into how these ML-based algorithms might be used to anticipate global temperature anomalies. It is possible to reliably anticipate global temperature anomalies by using a range of machine learning algorithms and input characteristics that are accessible on a variety of online sites. Regional studies, on the other hand, have not examined the relationship between the estimated temperature and the surrounding area's temperature readings in detail. A study that examines the impact of using temperature data from nearby stations as inputs, with the distance between stations being a consideration, may be of particular interest.
- In this research, many works are not analyzed in terms of their temporal perspective. Unfortunately, without these results, we cannot truly tell how accurate the technique offered is. To make it simpler to compare this strategy to others that might use the same data set, a set of evaluation measures must also be calculated.
- The size of the data set used for training and testing should be thoroughly examined to compare the various techniques accurately. This should be considered while performing the research since accurate findings greatly rely on the analyzed data set.
- Deep learning algorithms have recently shown extraordinary performance when it comes to classification difficulties. However, some positive findings from the research show that these approaches can be used to make solid predictions. In this area, further investigation and analysis are required.
- For RNN evaluation, the length of time series that must be examined to anticipate a single temperature value must be examined. A detailed analysis of the recurrent unit's organization should be provided in a similar spirit.
- A thorough assessment of statistical significance tests is required to assess the forecasting model's ability to give unbiased and accurate forecasts. Error magnitude and directional change error are used to determine relevant accuracy in these situations.

IV. The Resultant Effect of Climate Change On Farming

- CO2 affects agricultural production. Laboratory research reveals that CO2 may boost plant growth. Changing temperatures, ozone, and water and nutrient restrictions may reverse yield improvements.
- Extreme weather might hinder agricultural growth. Floods and droughts may lower agricultural output.
- Rising summer temperatures may dry up soils, causing drought.
- Warmer, wetter climates and higher CO2 levels favour weeds, bugs, and fungus.
- Rising CO2 may boost plant growth but lowers crop nutrition. Rising CO2 levels diminish protein and key mineral levels in wheat, soybeans, and rice. Rising CO2 threatens human health by reducing agricultural nutrition. Increased pest pressures and reduced pesticide effectiveness jeopardize human health.

V. Conclusion

Since its inception, there have been difficulties in climate science forecasting temperatures. Consequently, new approaches are always being developed to replace the old. There will be a new wave of computing that personal computers will no longer dominate. Internet of Things (IoT) refers to a new paradigm in which almost everything in our daily lives will somehow be linked to the internet. Machine learning and the internet of things go hand in hand. For farmers and rural communities alike, they may be a powerful force for growth in the advancement of agricultural technology and an effective answer to the challenges they face.

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