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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 seriously degrade the environment because of their inherent destructive potential. 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. In this paper, we have to use the proposed LSTM method and compare it to the proposed result in the RNN model. The best technique for temperature is LSTM, with a mean absolute error of 0.8137 degrees.

Keywords: Temperature Prediction, IoT, Machine Learning, RNN, LSTM.

I. 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 forecasts 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 the 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 the 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 and 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 US 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 summarise global warming's impacts.

II. 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 major problems 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. The 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 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.

Regarding affecting people's quality of life, temperature and humidity 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 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 between 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 the sensor's sensitivity 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. This model must collect big data 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. Please 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 humans and 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 Internet 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.

III. ENVIRONMENTAL TEMPERATURE PREDICTION USING MACHINE LEARNING TECHNIQUE

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 create predictions based on new data after it adequately represents the old data. A model's estimation of unknown parameters relies on a specific data set. 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 learnt without supervision in 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.

IV. PROPOSED METHOD

This section provides information on the work that is planned. In order to accurately estimate the temperature in the experiment, we are required to employ RNN and LSTM algorithms.

• LSTM: Since there may be delays of undetermined length between significant occurrences in a time series, LSTM networks are well-suited to categorizing, processing, and generating predictions based on time series data. This is because LSTM networks are recurrent neural networks.

• RNN in its most basic form: A recurrent neural network, often known as an RNN, is a kind of artificial neural network that belongs to the class of networks in which connections between nodes form a directed graph along a sequence. This enables it to display temporally dynamic behaviour throughout a time series.

4.1 Journal Working Process of model

1. Formulate the query and ascertain the information that is needed (completed)
2. Acquire the data
3. Locate and address any abnormalities or data points that are absent.
4. To get the data ready for the machine learning model, you need to clean and wrangle them.
5. Create a model of the starting point
6. Teach the model using the data that it was trained on.
7. Base your hypotheses on the results of the tests. 8. Evaluate your hypotheses in light of the established test parameters and compute your performance metrics.
8. If the performance is not up to par, make changes to the model, get new information, or experiment with other modelling strategies.
9. Perform findings interpretation and report them both graphically and quantitatively

4.2 Proposed Working flowchart

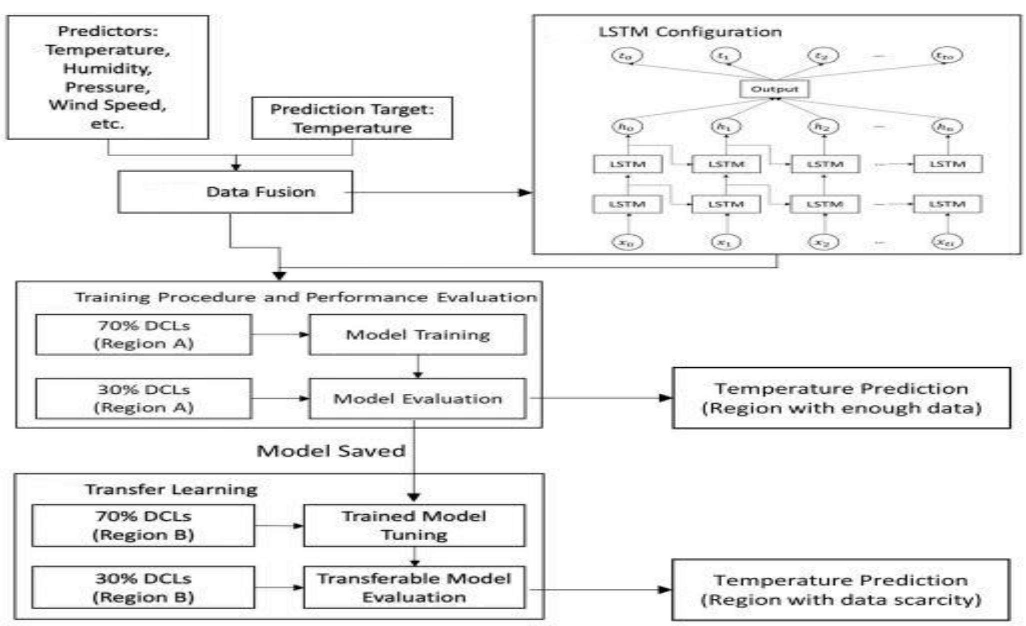
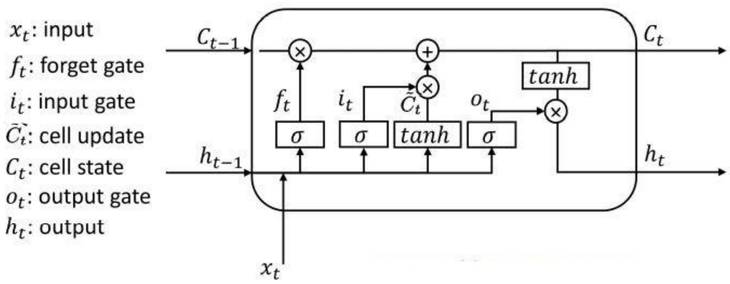


Figure 1. Proposed Working flowchart

Figure 1 shows the proposed work. Our work is divided into 4 steps, first, data fusion; second, proposed LSTM; third, training procedure and validation and last, model save with temperature prediction in terms of MSE.

4.3 Architecture of LSTM



$f_t = \sigma(w_f[h_{t-1}, x_t] + b_f)$	(1)
$i_t = \sigma(w_i[h_{t-1}, x_t] + b_i)$	(2)
$o_t = \sigma(w_o[h_{t-1}, x_t] + b_o)$	(3)

Figure 2. **Architecture of LSTM**

Figure 2 shows the architecture of the proposed LSTM. This architecture has components like input, forget gate, input gate, cell update, cell state, output gate, and output.

V. IMPLEMENTATION AND RESULT

5.1 Software :

The below figure mention all libraries for our implementation steps.

```

import pandas as pd
import numpy as np
import os
import glob
import matplotlib.pyplot as plt
from keras.layers import SimpleRNN, Dense, Dropout, LSTM
from keras.models import Sequential
from keras.models import model_from_json
```

Figure 3. Python library for proposed work

5.2 Dataset :

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	District
1912	22.965	24.17	28.024	31.609	33	31.1	27.18	25.999	27.661	26.686	23.167	21.096	Adilabad
1913	23.233	24.964	29.675	32.378	35.101	32.33	28.376	27.853	26.852	26.614	22.351	21.26	Adilabad
1914	22.708	24.058	28.554	32.16	32.434	32.286	27.008	26.479	26.762	25.25	21.657	20.216	Adilabad
1915	22.413	24.189	28.269	32.898	33.69	29.975	27.588	27.1	26.565	26.117	22.051	20.894	Adilabad
1916	21.963	22.996	28.156	30.432	34.193	32.5	27.96	26.899	26.491	26.089	23.558	20.526	Adilabad
1917	22.599	24.932	27.901	32.973	35.192	30.038	27.404	26.833	26.482	25.864	23.249	21.637	Adilabad
1918	22.171	24.722	27.891	29.792	32.966	30.733	27.861	25.406	27.432	27.157	24.343	20.63	Adilabad
1919	21.402	24.856	27.817	33.023	34.671	31.838	26.92	25.992	26.707	25.976	22.181	19.461	Adilabad
1920	23.312	25.207	29.182	29.945	33.747	29.65	26.531	27.075	26.535	26.098	23.249	22.181	Adilabad
1921	22.401	24.173	28.672	32.754	34.235	30.022	27.908	26.924	26.327	25.628	21.175	20.16	Adilabad

Dataset reference: www.indianwaterportal.org

Figure 4. Temperature Data

5.3 Parameters of result evaluation:

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 Error (MAE), 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).

5.4 Result

In this section, we have to explain the result of the sample RNN and LSTM model.

5.4.1 RNN

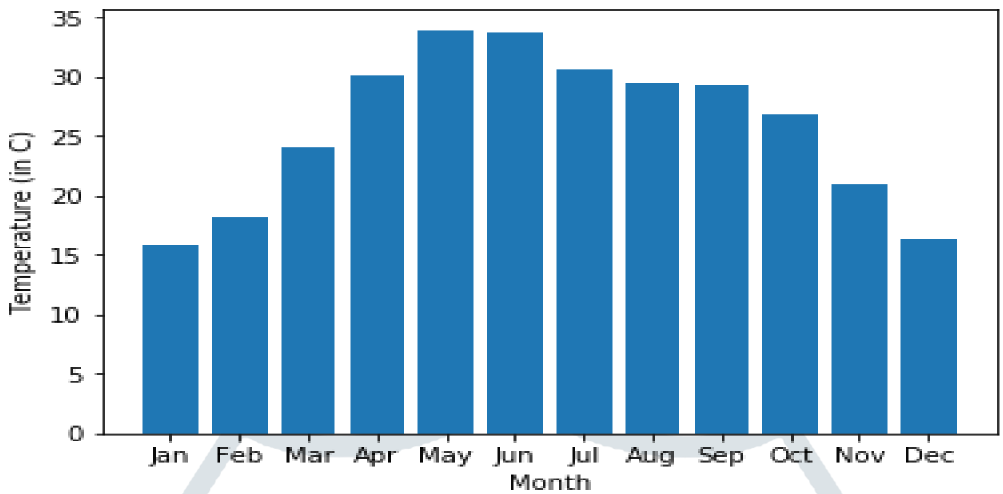


Figure 5. Temperature respect to month using RNN

Figure 5 shows the temperature concerning the month using RNN. X-axis month Jan to December and y-axis temperature.

5.4.2 LSTM

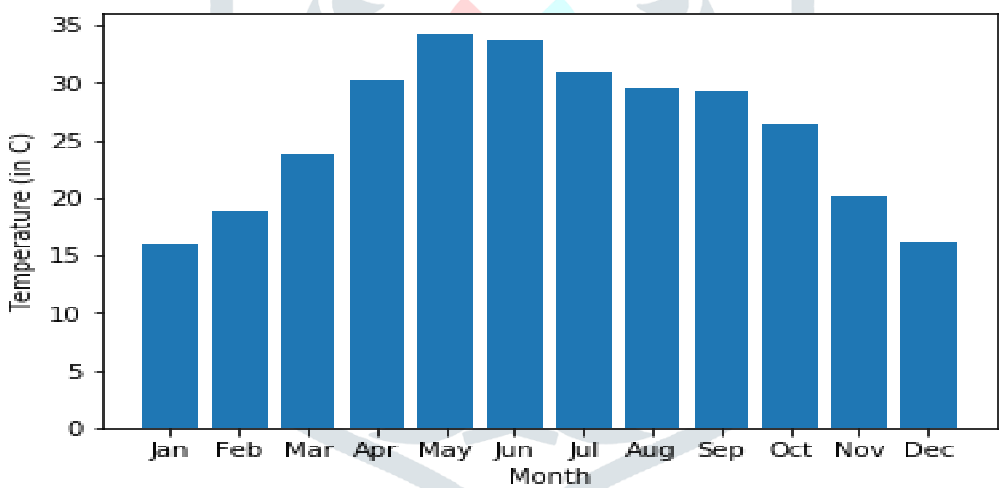


Figure 6. Temperature respect to month using LSTM

Figure 6 shows the temperature concerning the month using RNN. X-axis month Jan to December and y-axis temperature.

5.4.3 Comparison of actual distribution with predicted

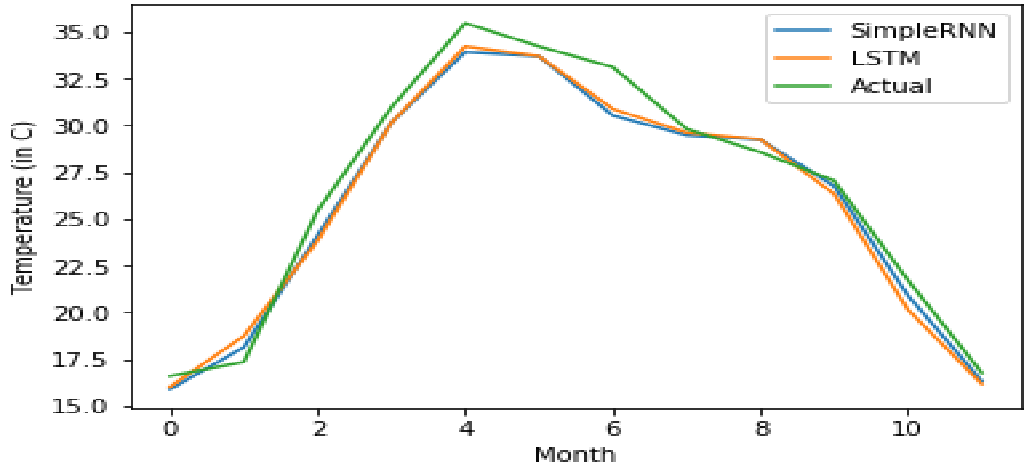


Figure 7. Comparison of actual distribution with predicted using RNN, LSTM.

Figure 7 compares the actual distribution with the predicted using RNN and LSTM. X-axis month Jan to December and y-axis temperature.

5.4.4 Comparison of mean absolute error for each model

Table 1. Comparison of actual distribution with predicted

Model	Mean Absolute Error
Simple RNN	0.92016
LSTM	0.8137

Table 1 shows the comparison of the actual distribution with the predicted. The best technique for temperature is LSTM, with a mean absolute error of 0.8137 degrees.

VI. 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. The 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. The best technique for temperature is LSTM, with a mean absolute error of 0.8137 degrees.

REFERENCES

[1] R. Salazar, A. Rojano, Irineo, and U. Schmidt, "A model for the combined description of the temperature and relative humidity regime in the greenhouse," in Proc. IEEE Ninth Mexican International Conference on Artificial Intelligence, Nov 8-13, 2010, pp. 114-117

[2] Ayham Omary, Ahmad Wedyan, Ahmed Zghoul, Ahmad Banihai, Izzat Alsmadi, "An interactive predictive system for weather forecasting", IEEE; June 2012

[3] John Abbot and Jennifer Marohasy , "Application of Artificial Neural Networks to Rainfall Forecasting in Queensland, Australia", Advances in Atmospheric Sciences; July-2012

[4] F. Mekanik, M.A. Imteaz, S. Gato-Trinidad, A. Elmahdi , "Multiple regression and Artificial Neural Network for long-term rainfall forecasting using large scale climate modes",Journal of Hydrology ,Vol – 503, October-2013

[5] R. K. Kodali, N. Rawat, L. Boppana, "WSN sensors for precision agriculture," in Proc. IEEE Region 10 Symposium, April 2014.

[6] T. Ojha, S. Misra, and N. S. Raghuwanshi, "Wireless sensor networks for agriculture: The state-of-the-art in practice and future challenges," Computers and Electronics in Agriculture, vol. 118, pp. 66-84, October 2015.

[7] G.Vamsi Krishna , "An Integrated Approach for Weather Forecasting based on Data Mining and Forecasting Analysis", International Journal of Computer Application,Vol – 120, June 2015

[8] Y. Song, S. Qin, J. Qu, Feng Liu , "The forecasting research of early warning systems for atmospheric pollutants: A case in Yangtze River Delta region", Atmospheric Environment; 2015

[9] M. Outanoute, A. Lachhab, A. Ed-dhak, A. Selmani, M. Guerbaoui, and B. Bouchikhi, "A neural network dynamic model for temperature and relative humidity control under Greenhouse," in Proc. IEEEPublishing in 2015 Third International Workshop on RFID AndAdaptive Wireless Sensor Networks(RAWSN), May 13-15, 2015, pp. 6-11.

[10] H. Yu, Y. Chen, S. G. Hassan, and D. Li, "Prediction of the temperature in a Chinese solar Greenhouse based on LSSVM optimized by improved PSO," Elsevier, pp. 94-102, January 2016.

[11] S. Salcedo-Sanz, R. C. Deo, L. Carro-Calvo, B. Saavedra Moreno, "Monthly prediction of air temperature in Australia and New Zealand with machine learning algorithms", Theoretical and Applied Climatology,Vol – 125, July-2016

[12] Xiao Yun Chen and Kwok Wing Chau, "A hybrid Double Feedforward Neural Network for Suspended Sediment Load Estimation", Water Resources Management (Vol - 30); May 2016

[13] Y. Hu, L. Piao and X. Chang, "Effect of environmental temperature on the flow inclination sensor with the structure of two-wire spherical sensitive cavity," 2017 IEEE 2nd Information Technology, Networking, Electronic and Automation Control Conference (ITNEC), 2017, pp. 1439-1443, doi: 10.1109/ITNEC.2017.8285035.

[14] MJ Alizadeh, M.R. Kavianpour, Ozgur Kisi; Vahid Nourani , "A new approach for simulating and forecasting the rainfall-runoff process within the next two months", Journal of Hydrology,Vol – 548, May-2017

[15] Prashant Biradar, Sarfraz Ansari, Yashavant Paradkar, Savita Lohiya , "Weather Prediction Using Data Mining", IJERD, Vol – 5, 2017

[16] K. Zhang et al., "Machine Learning-Based Temperature Prediction for Runtime Thermal Management Across System Components," in IEEE Transactions on Parallel and Distributed Systems, vol. 29, no. 2, pp. 405-419, 1 Feb. 2018, doi: 10.1109/TPDS.2017.2732951.

[17] Harvey Zheng, "Analysis of Global Warming Using Machine Learning", Computational Water, Energy; and Environmental Engineering,Vol – 7, July2018

[18] Neelam Mishra, Hemant Kumar Soni, Sanjiv Sharma, AK Upadhyay , "Development and Analysis of ANN Models for Rainfall Prediction by Using Time-Series Data", International Journal of Intelligent Systems and Applications; January-2018

[19] A. G. Salman, Y. Heryadi, E. Abdurahman, and W. Suparta, "Single-layer & multi-layer long short-term memory (LSTM) model with intermediate variables for weather forecasting," in Proc. 3rdInternational Conference on Computer Science and Computational Intelligence, 2018, pp. 89-98.

[20] D. Shinde and N. Siddiqui, "IOTS based environment change monitoring and controlling in a greenhouse using WSN," in Proc. 2018International Conference on Information, Communication, Engineering and Technology (ICICET), IEEE, Aug. 29-31, 2018.

[21] Y. Yue, J. Quan, H. Zhao, and H. Wang, "The prediction of greenhouse temperature and humidity based on LM-RBF network," inProc. 2018 IEEE International Conference on Mechatronics and automation, August 5-8, 2018, pp. 1537-1541.

[22] J. Muangprathub, N. Boonnam, S. Kajornkasirat, N. Lekbangpong, A. Wanichsombat, and P. Nillaor, "IoTs and agriculture data analysis for smart fan," Elsevier, June 2018, pp. 467-474.

[23] S. Hualin, X. Bin, F. Yun and L. Guohui, "Simulation Analysis of Temperature Distribution of Oil-immersed Self-cooled Transformer under Different Environmental Conditions," 2019 22nd International Conference on Electrical Machines and Systems (ICEMS), 2019, pp. 1-4, doi: 10.1109/ICEMS.2019.8922368.

[24] H. Tao, L. Junjie, S. Yu, C. Yongjian and L. Zhenyu, "Predictive analysis of indoor temperature and humidity based on BP neural network single-step prediction method," 2020 IEEE 3rd International Conference on Information Systems and Computer Aided Education (ICISCAE), 2020, pp. 402-407, doi: 10.1109/ICISCAE51034.2020.9236853.

[25] A. Buzaboon, H. Albuflasa, W. Alnaser, S. Shatnawi, K. Albinali and E. Almohsin, "Temperature-dependency of Environmental Higher Education Ranking Systems," 2021 Third International Sustainability and Resilience Conference: Climate Change, 2021, pp. 83-87, doi: 10.1109/IEEECONF53624.2021.9667995.

[26] M. Purushotham Reddy, A. Aneesh, K. Praneetha and S. Vijay, "Global Warming Analysis and Prediction Using Data Science," 2021 Fifth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), 2021, pp. 1055-1059, doi: 10.1109/I-SMAC52330.2021.9640944.

[27] DR, "Tackling Climate Change with Machine Learning", ACM Computing Surveys, Vol. 55, No. 2, Article 42. Publication date: February 2022.