International Journal of Scientific Research and Engineering Development-– Volume 8 Issue 4, July-Aug 2025
Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Enhancing Weather Forecasting Accuracy Using LSTM-Based Deep Learning Models

Jitendra Kumar Saini[1], Dr.Varun Bansal[2],Arun Saini[3],Naman Saini[4]
[1](CSE, Shobhit University, Gangoh
Email: jitendra.saini@shobhituniversity.ac.in)
[2] (CSE, Shobhit University, Gangoh
Email : Varun.bansal@shobhituniversity.ac.in)
[3](CSE, Shobhit University, Gangoh
Email : arun.saini@shobhituniversity.ac.in)
[4] (CSE, Shobhit University, Gangoh
Email : naman.saini@shobhituniversity.ac.in)

Abstract:

This literature review analyzes the limitations of deep learning-based weather forecasting models. Models such as LSTM, BiLSTM, GAN-LSTM and FBVS-LSTM currently used are generally trained on single-location and sparse data, which limits their scalability and transferability to other climate domains. Most studies lack transfer learning, multi-location validation and real-time implementation. Long-term forecasting, feature importance analysis and interpretability have also been ignored. Rainfall forecasting still needs improvement, particularly during times of high variability. Furthermore, the majority of models do not make use of contemporary architectures like transformers and are instead based on outdated DL frameworks. . The study also shows that sentiment and situation-aware forecasting cannot be done with single-domain models. Future studies should focus on interpretable, adaptive, and real-time forecasting systems, multi-location data, and contemporary DL methodologies.

***Keywords* — LSTM, CNN, GA, RNN, NWP, ANN Deep learning.**

I. INTRODUCTION

Weather forecasts have a big impact on human life worldwide. Solving mathematical equations based on climatic conditions requires a significant amount of computing power. Deep learning technology has made it possible for humans to discover a wide range of intricate geophysical phenomena. Numerical simulation can predict it. This can somewhat aid in comprehending the intricate laws of the planet. Weather forecasts are needed in many fields, such as agriculture, aviation, disaster relief, and daily planning. Reducing financial risk and improving public safety are two benefits of accurate weather forecasts. Traditional forecasting techniques such as numerical weather prediction (NWP) require a lot of computing power and rely mainly on complex physical models. However, nonlinear patterns and time-dependencies in meteorological data are often difficult for these models to understand. The development of deep learning in recent years has provided new opportunities to increase the accuracy of weather forecasts. It turns out that long short-term memory (LSTM) networks are one of the most powerful deep learning architectures for modelling time series data because of their ability to recognize long-term dependencies and manage sequential patterns. Through the use of memory cells and gating mechanisms that address problems such as vanishing gradients, studies have found that LSTM networks outperform traditional recurrent neural networks (RNNs). This study investigates the use of deep learning models based on LSTM to improve the accuracy of weather forecasts. The model uses historical weather data to understand complex time relationships and enables the production of accurate short-term and medium-term forecasts. The study uses common evaluation parameters such as MAE, MSE, RMSE, and R2 and by comparing the performance of LSTM with traditional forecast models, the study also measures how well LSTM captures the dynamics of the weather system.

II. Literature Review

Ref. No.	Methodology / Tools	Objective	Research Gap	Key Contribution	Publisher
1	Bibliometric Analysis	To improve sequence prediction and long-term data processing by incorporating LSTM into the RNN framework, which will increase the accuracy of weather forecasts.	**Current LSTM forecasting models are limited by a lack of external features, data augmentation, and broader factors.**	Accuracy is increased and complex, long-sequence weather data is handled efficiently by LSTM over RNN.	(ICIAAI 2024)
2	CNN - LSTM encoder-decoder model	To create a CNN-LSTM encoder-decoder model that is computationally efficient for forecasting upcoming weather photos	**The model's scalability and generalisability are limited because it was trained on a single region with sparse data and lacked validation across multiple regions and transfer learning.**	Developed a CNN-LSTM encoder-decoder model for multi-variable weather forecasting with a single architecture that is computationally efficient and generalised.	IEEE Xplore
3	LSTM + GA	This demonstrates how LSTM technology is dependable and efficient in weather forecasting.	**One of the biggest challenges in this work was the quality and quantity of available data.**	The significance of precise weather forecasting for crucial decision-making across multiple industries	MDPI
4	Bi-LSTM models	To develop a flexible, lightweight, and purely data-driven Bi-LSTM-based deep learning model for short-term weather forecasting	**No Attention Given to Longer-Term Forecasting:**	shown cost-effectiveness and adaptability appropriate for localised forecasts.	Springer
5	EMD - LSTM model	A deep learning network was created to forecast urban weather conditions based on the data characteristics, and experiments demonstrated that it was feasible.	**The study is devoid of feature importance analysis and explainability.**	The experimental findings demonstrate that our EMD-LSTM model design outperforms conventional models in terms of forecasting accuracy and efficiency	MDPI
6	GANs-LSTM Mod	Making certain that the right mix of	**GANs LSTM model have produced**	An essential meteorological parameter for ecological,	IEEE

	el	meteorological inputs is used in order to produce the best model possible.	**various T estimation results.**	physical, and biological research is soil temperature (Ts).	
7	FBVS-LSTM	To use forward-backward decay mechanisms to handle multivariate time series with high missing rates in order to accurately predict the weather.	**investigating the generalization and scalability of FBVS-LSTM in a variety of climatic zones and longer-term weather forecasting scenarios.**	a new LSTM-based model that uses variable-specific missing information and forward-backward decay to address MNAR missingness for precise short-term weather forecasting.	MDPI
8	LSTM	The study looks at deep learning's potential in weather and meteorological applications and makes recommendations for further study on network architecture and LSTM variations.	**calls for refinement for rainfall prediction, mainly throughout high-variability periods**	LSTM with improves accuracy	AJRCOS
9	Naive Bayes and Chi-Square	Via a web-based system, weather forecasting employs	**To improve prediction accuracy by working with other classificati**	Improved accuracy with other classification algorithms	IJCA

		Naive Bayes and Chi-Square for precise prediction.	**on algorithms and adding more weather condition attributes.**		
10	BiLSTM-ADASYN algorithm.	To improve accuracy using BiLSTM - ADASYN algorithm to develop daily weather forecast model for Soekarno-Hatta Airport.	**This study only looks at one location-specific model, which makes it obvious that there is a significant research gap regarding the model's generalisability and transferability to other geographic areas.**	creating a daily weather forecasting model with increased accuracy using the BiLSTM-ADASYN algorithm.	JPPIPA
11	LSTM, NWP	To compare the accuracy and stability of a deep learning-based time series forecasting model with more conventional Numerical Weather Prediction (NWP) techniques in order to determine which is best for predictin	**To improve the precision and effectiveness of weather forecasting, current research does not fully integrate physics-based NWP techniques with data-driven LSTM models.**	For weather forecasting accuracy, LSTM performs better than NWP models.	IJST

		g the weather.			
12	Transformer, LSTM	To employ self-attention Transformer models for precise time series prediction.	**It is possible to generalize self-attention mechanisms to learn relationships between two arbitrary points in spatiotemporal space.**	Offered a transformer-based method for time series data forecasting.	arXiv: 2001.08317v1 [cs.LG] 23 Jan 2020

III. OBJECTIVE:

After the comprehensive review, find out some Objective:

1. LSTM forecasting models must include external features.
2. To use sparse and limited data, data augmentation can be used.
3. For regional generalization capability, transfer learning can be used.
4. Long-term weather forecasting models can be used.
5. Tools can be included to interpret capability and feature importance.
6. FBVS-LSTM can be used for rainfall forecasting in different climates.
7. To increase accuracy, deep learning neural networks can be combined with LSTM.

IV. CONCLUSIONS

This literature review extensively highlights the strengths and limitations of current deep learning models particularly LSTM and its variants in weather forecasting. In handling complex temporal patterns, LSTM-based models have outperformed traditional RNN and NWP systems; however, they are still hampered by several critical issues. Many models have been trained on single-location and sparse datasets, which greatly limits their scalability and transferability across diverse geographic and climatic conditions. Many studies lack tools for feature importance analysis and interpretability, which are crucial to build trust and transparency in practical deployments. Despite the advent of powerful architectures such as Transformers, many current models rely heavily on traditional LSTM frameworks. We should instead explore hybrid or more contemporary alternatives. It is often observed that infrequent and incomplete data impacts model accuracy to a great extent and new techniques can help address these problems. It has been observed that very few models use transfer learning or multi-location validation, which is essential for building predictive systems. So after reading the research paper we came to know that traditional LSTM used is not enough. Now our goal is to make such a hybrid model that achieves high accuracy, stability.

REFERENCES

[1] Zhang, F. (2024, October). Weather Forecasting and Analysis with LSTM Based on Deep learning. In Proceedings of the 2024 2nd International Conference on Image, Algorithms and Artificial Intelligence (ICIAAI 2024) (Vol. 115, p. 165). Springer Nature.

[2] Fan, M., Imran, O., Singh, A., & Ajila, S. A. (2022, December). Using cnn-lstm model for weather forecasting. In 2022 IEEE International Conference on Big Data (Big Data) (pp. 4120-4125). IEEE.

[3] Teixeira, R., Cerveira, A., Pires, E. J. S., & Baptista, J. (2024). Enhancing weather forecasting integrating LSTM and GA. Applied Sciences, 14(13), 5769.

[4] Zenkner, G., & Navarro-Martinez, S. (2023). A flexible and lightweight deep learning weather forecasting model. Applied Intelligence, 53(21), 24991-25002.

[5] Chen, G., Liu, S., & Jiang, F. (2022). Daily weather forecasting based on deep learning model: A case study of Shenzhen city, China. Atmosphere, 13(8), 1208.

[6] Li, Q., Hao, H., Zhao, Y., Geng, Q., Liu, G., Zhang, Y., & Yu, F. (2020). GANs-LSTM model for soil temperature estimation from meteorological: a new approach. Ieee Access, 8, 59427-59443.

[7] Holmstrom, M., Liu, D., & Vo, C. (2016). Machine learning applied to weather forecasting. Meteorol. Appl, 10(1), 1-5.

[8] Qasim, O. A., Alhayani, M. Y., & Noori, M. S. (2024). Deep Learning-based Weather Prediction: A Focused Case Study on Mosul City, Iraq. Methodology.

[9] Biswas, M., Dhoom, T., & Barua, S. (2018). Weather forecast prediction: an integrated approach for analyzing and measuring weather data. International Journal of Computer Applications, 182(34), 20-24.

[10] Danitasari, F., Ryan, M., Handoko, D., & Pramuwardani, I. (2024). Improving Accuracy of Daily Weather Forecast Model at Soekarno-Hatta Airport Using BILSTM with SMOTE and ADASYN. Jurnal Penelitian Pendidikan IPA, 10(1), 179-193.

[11] Surve, R. B., Lanjewar, U. A., & Rewatkar, L. R. (2025). Deep Learning and NWP: An Evaluation for Accurate Weather Forecasting. Indian Journal of Science and Technology, 18(28), 2273-2282.

[12]

ERROR: syntaxerror
OFFENDING COMMAND: --nostringval--

STACK: