IJARCCE
ISSN (O) 2278-1021, ISSN (P) 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.102 ⁜ Peer-reviewed journal & Refereed journal ⁜ Vol. 12, Issue 12, December 2023
DOI: 10.17148/IJARCCE.2023.121212

Weather Forecasting Using Spatial Feature Based LSTM Model

Prof. Nilam Honmane[1], Omkar Jadhav[2], Aditya Gavate[3], Sanika Nimse[4], Roshan Jadhav[5]

Assistant Professor, Department of Information Technology, Zeal College of Engineering and Research, Narhe[1]

UG Student, Department of Information Technology, Zeal College of Engineering and Research, Narhe[2-5]

Abstract: In recent years, the field of short-term predictions has witnessed substantial advancements due to the rapid growth in data-driven approaches. To contribute to this area of research, a novel model named the Spatial Feature Attention-based LSTM (Long Short-Term Memory) has been developed, aiming to enhance the accuracy and reliability of short-term predictions. The advent of deep learning techniques has revolutionized various domains and one such domain where these techniques have made significant strides in time series forecasting. Weather forecasting is crucial for various industries, including agriculture, transportation, and disaster management. The accuracy of short-term weather predictions significantly impacts decision-making and planning.

Keywords: LSTM Model, Short Term Prediction, Spatial Feature, Weather Forecasting.

I. INTRODUCTION

Weather forecasting is an intricate process involving the anticipation of weather conditions for a specific geographical area and period. This endeavour relies on the amalgamation of scientific principles, advanced technology, and the application of fundamental laws of physics. Various meteorological parameters, including but not limited to atmospheric pressure, temperature, humidity, wind speed, and precipitation, are systematically collected over an extended duration.

These data serve as a comprehensive repository of quantitative information, allowing for an in-depth depiction of the prevailing atmospheric conditions at a given point in time. These meteorological observations form the foundation upon which the science of atmospheric processes is built, enabling meteorologists to discern intricate patterns and phenomena in the atmosphere. Ultimately, this wealth of knowledge serves as the cornerstone for the development of forecasts that offer insights into the forthcoming changes in the atmospheric state.

Artificial Intelligence (AI) is like a super-smart computer system that can help us do many important things. It's not just about making our lives better or helping businesses grow, but it can also save our planet. AI can help us tackle climate change, the big problem where the Earth gets too hot. It can predict when crazy weather is coming, like big storms or heat waves, so we can prepare and stay safe.

Weather forecasting plays an important role in shaping the consequences of impending weather conditions in the fabric of our daily lives. It offers a crucial vantage point for individuals, communities, and governing bodies to strategize effectively in response to the looming spectres of snowfall, rainfall, scorching heat waves, and potential inundations.

This predictive insight into the atmospheric future empowers the general populace and government agencies take to early action to avoid the potentially disastrous effects of bad weather.

It's like a proactive tool for preparation, preventing harm to people, property, and essential infrastructure In essence, weather forecasting serves as a potent instrument of preparation and mitigation, ensuring the preservation of life, property, and infrastructure.

In today's world, accurate weather forecasts are crucial for various purposes. Weather warnings save lives and property, temperature and precipitation forecasts are vital for agriculture and commodity trading, and utility companies rely on temperature forecasts to plan for future energy demand.

Long Short-Term Memory (LSTM) models, which are a type of recurrent neural network (RNN), use a specific algorithm to perform their computations.

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.102 ⁜ Peer-reviewed journal & Refereed journal ⁜ Vol. 12, Issue 12, December 2023
DOI: 10.17148/IJARCCE.2023.121212

II. LITERATURE SURVEY

Masoom Ali Raza Suleman and S.Shridevi "Short-Term Weather Forecasting Using Spatial Feature Attention Based LSTM Model", [1] The information about future weather conditions helps to maintain commercial, economic, environmental and social interests.

For example, weather forecasts in agriculture help farmers to plan their harvests and workload, utility companies to purchase sufficient supplies of power and natural gas, inventories and stores to match the demand and supply of resources, the public to plan their outdoor activities and government to communicate the weather warnings to the general public to protect their life and property within sufficient time.

Patricia de Rosnay1, Nemesio Rodriguez-Fernandez [2], Joaquin Munoz-Sabater, Clement Albergel, David Fairbairn, Heather Lawrencel, Stephen English1, Matthias Drusch3 and Yann Kerr [2]" Smos Data Assimilation for Numerical Weather Prediction" Several operational centres started to investigate the use of L-band passive microwave brightness temperature observations from the Soil Moisture and Ocean Salinity mission (SMOS) and the Soil Moisture Active and Passive mission (SMAP) for NWP applications.

At the European Centre for Medium-Range Weather Forecasts (ECMWF) the SMOS brightness temperature data has been passively implemented in the Integrated Forecasting System (IFS) for monitoring purposes. SMOS brightness temperature monitoring and data assimilation rely on a forward modelling approach. Another approach consists of retrieving soil moisture products from L-band measurements based on a neural network (NN) approach. Training the NN on the land surface model used for assimilation ensures consistency between the soil moisture product and the model climatology whereas it preserves the satellite measurements dynamics.

Jatinder Kaur and Gursewak Singh, [3] state that in " Types of Weather Forecasting and its Importance ", In this paper weather forecasts provide critical information about future weather. Weather forecasting encompasses a spectrum of methodologies, ranging from sky observation to sophisticated computational models, each contributing to the holistic analysis and prediction of atmospheric conditions. Weather forecasts come in different time frames, whether for tomorrow or several months ahead. They rely on essential factors like temperature, wind speed, and relative humidity. These elements are especially crucial for agriculture and various industries heavily influenced by weather conditions.

Govind Kumar Rahul, Saumya Singh, Saumya Dubey,[4]"Weather Forecasting Using Artificial Neural Networks", Several projects and works have been done in the field of forecasting of Temperature and Pressure. This will help us interpret our project more effectively; a few of those works are discussed below, De used Artificial Neural Network for only the rain season to predict the minimum and maximum temperature.

It forecasted the temperature of 3 months i.e., June, July and August by referring to weather conditions from months January to May. This is a model having a single hidden layer with 2 nodes in the hidden layer. The maximum error that was recorded was 5%. Mohsen Ayati& Zahra Mohebi uses Artificial Neural Network to forecast the temperature of the coming day. They divided the data into 4 sections, each section representing a season and each season had its separate network. MLP was used to train the network and the data of 10 years, i.e., 1996-2006 was considered. The error varied between 0-2 MSE in the result.

Ayham Omary, Ahmad Wedyan, Ahmed Aghoul[5] "An Interactive Predictive System for Weather Forecasting", This literature review summary on efficiently use the limited amount of water under the impact of global climate change or to resourcefully provide adequate time for flood and drought warning, there is a need to seek an advanced modelling technique for improving stream flow forecasting on a short-term basis. Reanalysis is an intelligent use of past information with modern modelling to create consistent, long-term, spatially extended data sets (meteorology, climate, production etc). Forecasting is the prediction of outcomes based on varying degrees and different approaches (i.e., deterministic, statistical, semi-empirical and artificial intelligence).

III. METHODOLOGY

3.1) Block Diagram

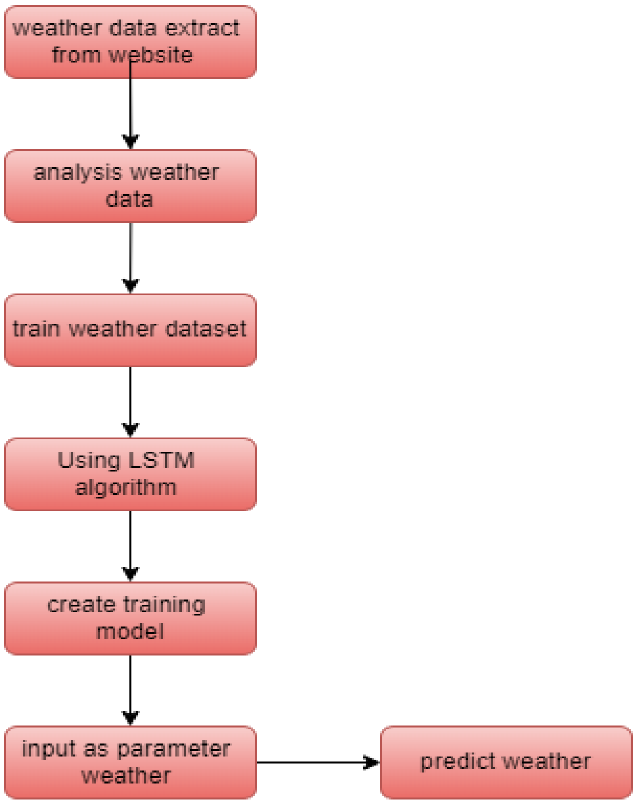
To start with this project of weather prediction with the help of Recurrent Neural Networks and Back Propagation, first of all, the weather information of the previous years from the Regional Meteorological Centre (RMC), India Meteorological Department (IMD).

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁒ Peer-reviewed journal & Refereed journal ⁒ Vol. 12, Issue 12, December 2023

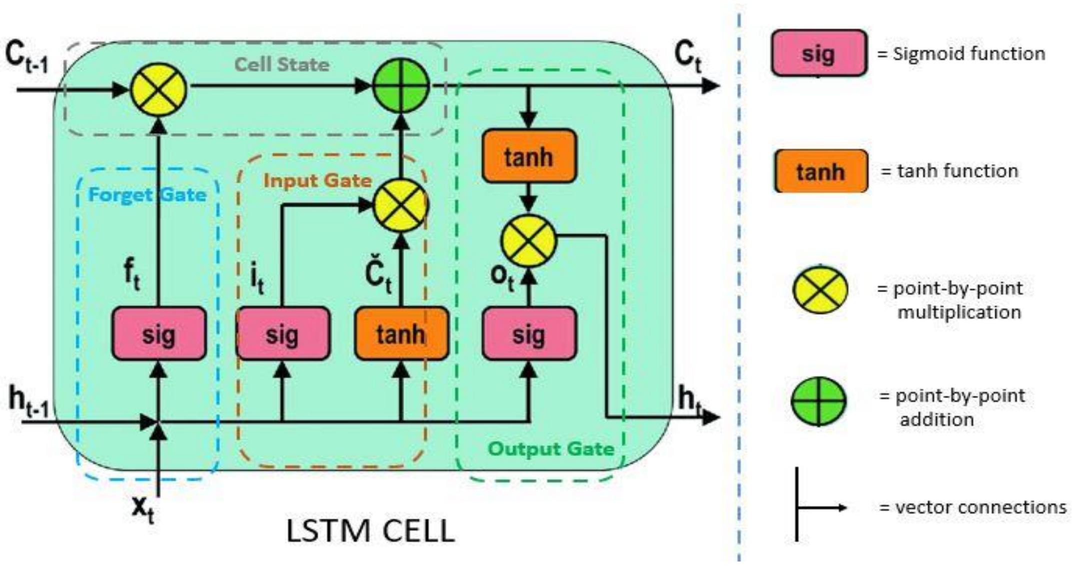
DOI: 10.17148/IJARCCE.2023.121212



When training an RNN with LSTM units, we follow a supervised approach. We use an optimization technique like gradient descent, coupled with backpropagation through time, to calculate the necessary gradients for adjusting each weight within the LSTM network. This adjustment is done in alignment with how the error at the LSTM network's output layer changes concerning the specific weight.

3.2) Components

The primary algorithm within an LSTM model involves a set of gates and memory cells that control the flow of information through the networks. These gates include:



IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁘ Peer-reviewed journal & Refereed journal ⁘ Vol. 12, Issue 12, December 2023

DOI: 10.17148/IJARCCE.2023.121212

1. Forget Gate

The forget gate is responsible for deciding what information from the previous cell state should be retained and what should be discarded. It takes as input the previous cell state and the current input and outputs a value between 0 and 1 for each element in the cell state. A value of 1 means "keep," and a value of 0 means "forget."

Here is the equation for the forget gate.

- $F_t = \sigma (X_t{}^{*}U_f + H_{t-1} * W_f)$

here

- **X_t:** input to the current timestamp.
- **U_f:** weight associated with the input
- **H_{t-1}:** The hidden state of the previous timestamp
- **W_f:** It is the weight matrix associated with the hidden state

2. Input Gate

The input gate determines which new information should be stored in the cell state. It takes the current input and the previous cell state as input and produces a candidate cell state. The input gate then combines this candidate cell state with the forget gate's output to update the cell state.

The input gate is used to extract the importance of the new data carried by the input. Here is the equation of the input gate

- $i_t = \sigma (X_t{}^{*}U_i + H_{t-1} * W_i)$

here,

- **X_t:** input to the current timestamp t.
- **U_i:** weight matrix of input
- **H_{t-1}:** The hidden state of the previous timestamp
- **W_i:** It is the weight matrix of input associated with the hidden state

To update the cell state in LSTMs, we consider both the hidden state from the previous time (t-1) and the input at the current time (t).

3. Output Gate

The output gate controls what information is output from the cell state to produce the final hidden state for the current time step. It takes the current input and the previous cell state as input and produces the new hidden state, which also becomes the output for that time step.

Here is the equation of the Output gate,

- $o_t = \sigma (X_t{}^{*}U_o + H_{t-1} * W_o)$

Its value lie between 0 and 1 because of this sigmoid function. Now to calculate the current hidden state, we will use Ot and tanh of the uploaded cell state

As shown below,

- $H_t = O_t * \tanh(C_t)$

The hidden state is a function of Long-Term Memory (C_t) and the current output.

4. TensorFlow

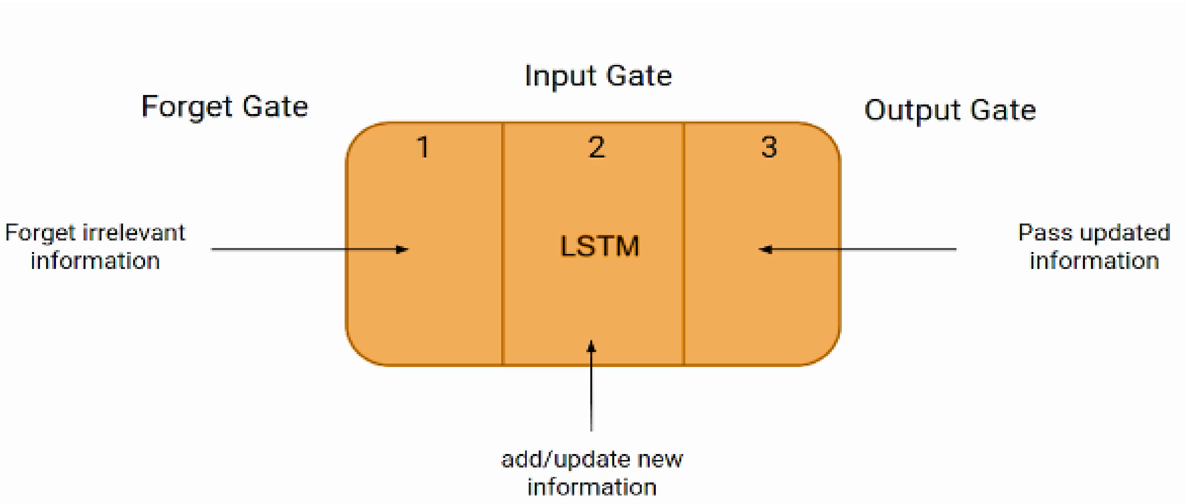
TensorFlow is a free and open-source software library and artificial intelligence. It is used across a range of tasks and has a particular focus on training and inference of deep neural networks. TensorFlow can be used in a wide variety of programming languages, including Python, JavaScript, C++, and Java.

3.3) Proposed System

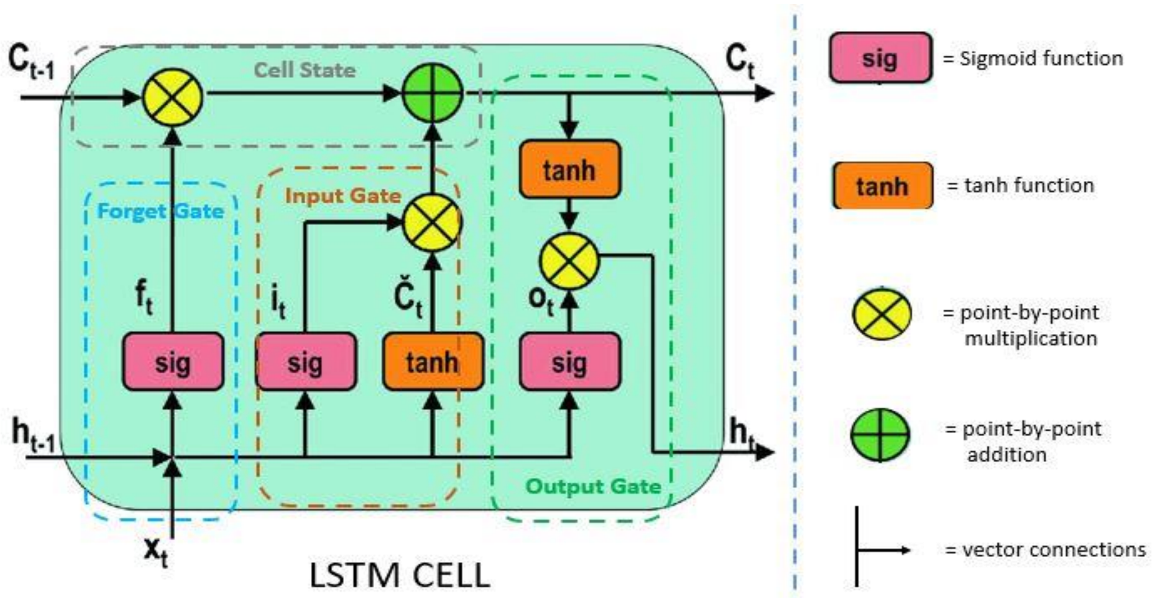
In this LSTM model, we use Deep Learning. The system is trained with machine learning, deep learning and TensorFlow, Keros which are useful for import functionalities like developing deep learning models, data visualization and image and data manipulation.

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.102 ⁜ Peer-reviewed journal & Refereed journal ⁜ Vol. 12, Issue 12, December 2023
DOI: 10.17148/IJARCCE.2023.121212

- Data Collection and Pre-processing
- Feature Selection
- LSTM Model Architecture
- Training the Model
- Hyper-parameter Tuning
- Evaluation Metrics
- Comparison with Baseline Models
- Visualization
- Analysis and Interpretation
- Future Work
- Deployment



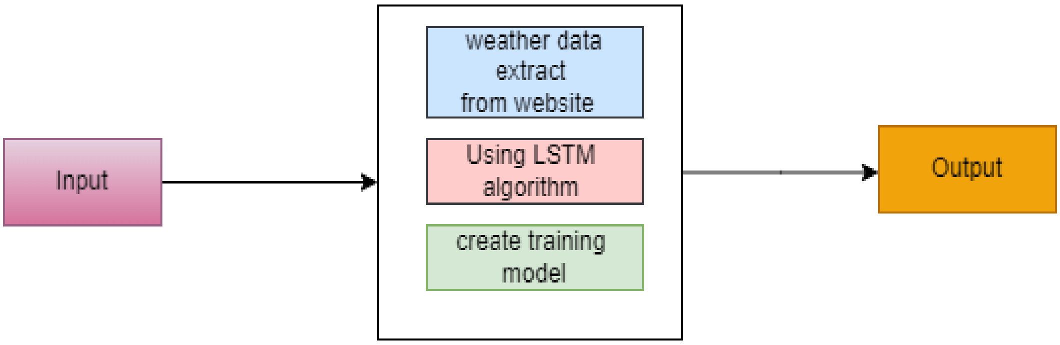
3.4) Model Design



IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.102 ⁕ Peer-reviewed journal & Refereed journal ⁕ Vol. 12, Issue 12, December 2023
DOI: 10.17148/IJARCCE.2023.121212

3.5) Process Flow



- Gather historical weather data, which may include temperature, humidity, wind speed, and other relevant features.
- Perform data preprocessing, including normalization, scaling, and encoding categorical variables.
- Divide the preprocessed data into training, validation, and test sets.
- Choose the appropriate LSTM architecture for your weather forecasting task.
- Consider variations of LSTM models, such as bidirectional LSTM or stacked LSTM, depending on the complexity of the task.
- Design the LSTM model architecture, including the number of layers, hidden units, and input features.
- Train the LSTM model using the training dataset. Set hyperparameters like learning rate, batch size, and epochs. Monitor training progress and use the validation dataset to prevent overfitting.
- Continuously monitor the environment with the camera and update image processing and motor control in real-time.
- Evaluate the LSTM model's performance on the test dataset using appropriate metrics such as Mean Absolute Error (MAE) or Root Mean Squared Error (RMSE). Visualize and analyze the model's predictions and compare them to actual weather observations.
- Deploy the trained LSTM model for real-time or batch weather forecasting.

IV. CONCLUSION

In conclusion, the development and implementation of a Short-Term Weather Forecasting Model based on Long Short-Term Memory (LSTM) architecture has yielded promising results and significant insights into the realm of meteorological predictions. This project set out to address the challenge of accurately forecasting weather conditions over short time horizons, a critical task with far-reaching implications for various sectors, including agriculture, transportation, and disaster management.

The Short-Term Weather Forecasting Model using LSTM presented in this project contributes to the field of meteorology by offering an effective and accurate solution for predicting short-term weather conditions. We hope this research will be a valuable resource for meteorologists, researchers, and decision-makers seeking to leverage advanced machine-learning techniques to enhance our understanding of weather patterns and improve the reliability of short-term weather forecasts. The potential benefits of this model extend to various sectors, fostering resilience in the face of ever-changing weather conditions.

REFERENCES

[1] MASOOMA ALI RAZA SULEMAN 1 AND S. SHRIDEVI “Short-Term Weather Forecasting Using Spatial Feature Attention Based LSTM Model” 04 August 2022
[2] SMOS DATA ASSIMILATION FOR NUMERICAL WEATHER PREDICTION Patricia de Rosnay1, Nemesio Rodriguez-Fernandez 2 , Joaquin Munoz-Sabater ˜ 1 , Clement Albergel ´ 1,4 , David Fairbairn 1 , Heather Lawrence1 , Stephen English1 , Matthias Drusch3 and Yann Kerr, 978-1-5386-7150-4/18/$31.00 ©2018 IEEE
[3] JatinderKaur and Gursewak Singh, "Types of Weather Forecasting and its Importance” 05 January 2021
[4] Govind Kumar Rahul, Saumya Singh, Saumya Dubey, "Weather Forecasting Using Artificial Neural Networks" 978-1-7281-7016-9/20/$31.00 ©2020 IEEE
[5] Ayham Omary, Ahmad Wedyan, Ahmed Aghoul “An Interactive Predictive System for Weather Forecasting”, 978-1-4673-1550-0/12/$31.00 ©2012 IEEE
[6] Weather Forecasting Models, Methods and Applications AA Iseh. A. J.1 Woma. T. Y.1,2, International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 2 Issue 12, December- 2013
[7] Weather Forecasting in India: A Review Vijay Kumar Didal1 , Brijbhooshan1, Anita Todawat2 and Kamlesh Choudhary2, ISSN: 2319-7706 Volume 6 Number 11 (2017) pp. 577-590