Deep Learning-Based Multivariate Forecasting of Rainfall, Temperature, and Humidity Patterns

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I. Literature Review

A. Machine learning techniques to predict daily rainfall amount

Chalachew Muluken Liyew et al. [1] have proposed data mining and machine learning techniques to predict daily rainfall amounts. Three machine learning algorithms, namely Multivariate Linear Regression (MLR), Random Forest (RF), and Extreme Gradient Boost (XG- Boost) are analyzed and compared for their performance in predicting rainfall. The Pearson correlation technique is used to select relevant environmental variables that are used as input for the machine learning model. Root mean squared error (RMSE) and Mean Absolute Error (MAE) are used as performance measures for the machine learning models. The study concludes that the Extreme Gradient Boost algorithm performs better than the other two algorithms in predicting daily rainfall amounts. The paper suggests that incorporating sensor data could potentially improve the accuracy of rainfall prediction.

B. Machine learning-based weather prediction model for short-term weather prediction in Sri Lanka

In 2021, K.M.S.A. Hennayake et al. [2] proposed a machine learning-based weather prediction model for short-term weather prediction in Sri Lanka. The research focuses on using a multivariate Long Short-Term Memory Network (LSTM) trained on historical weather observational data to predict temperature for a specific weather station in Sri Lanka. The research uses previous weather observational data from Sri Lankas Colombo weather station from 2010/01/01 to 2019/11/01 to train a machine learning model for weather prediction. Standard evaluation approaches are used to assess the models performance, including the determination of Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), and Mean Absolute Percentage Error (MAPE) values. The machine learning model, notably the multivariate Long Short-Term Memory Network (LSTM), performed exceptionally well in forecasting temperature for the selected Sri Lanka weather station. The models Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), and Mean Absolute Percentage Error (MAPE) scores were 1.37482F, 0.98985F, and 1.211372% respectively which is exceedingly low, suggesting its ability to reliably anticipate weather based on historical observational data.

C. Sequence to sequence weather forecasting with long short-term memory recurrent neural networks

Mohamed Akram Zaytar et al. [3] used a deep neural network architecture with multi-stacked LSTMs to map sequences of weather values for time series weather prediction. The paper used approximately 15 years (2000-2015) of hourly meteorological data to train the model for weather forecasting. The data was often inconsistent, with missing values or values out of range. To address this, the authors used a method of forward-filling missing or noisy values using previous points in time. This helped in cleaning the data before training the model. After cleaning the data, all the values were normalized to points in the range of [-1, 1]. This normalization was done to avoid training problems and enable weight decay and Bayesian estimation with standardized inputs. The dataset used in this paper focused on weather data for 9 cities in Morocco, including temperature, humidity, and wind speed. The goal was to forecast 24 and 72 hours worth of weather data for these cities.The paper evaluated the performance of the LSTM-based neural network architecture for weather forecasting using the Mean Squared Error (MSE) as a score function. The results showed that the LSTM-based neural networks were competitive with traditional methods and could be considered a better alternative for forecasting general weather conditions. The quality of the predictions was evaluated using the untrained test data, and the Mean Squared Error (MSE) was calculated. However, specific numerical results or comparisons with other methods were not mentioned in the provided sources

D. Weather prediction using LSTM neural networks

Anitej Srivastava et al. [4] propose the use of Long Short Term Memory (LSTM) neural networks for weather prediction. LSTM is a type of recurrent neural network (RNN) that has the ability to store key data and remember it for the long term using gates. The model combines LSTM with optimizations such as Gaussian and Median filtering to improve accuracy in long-range weather prediction. These filtering techniques help the model form a more informed pattern The paper does not explicitly mention the specific data used for weather prediction. It focuses on the use of Long short-term memory (LSTM) neural networks and optimizations such as Gaussian and Median filtering to improve accuracy in long-range weather prediction. However, it can be inferred that the data used for training and testing the LSTM model would typically include historical weather data such as temperature, humidity, wind speed, and precipitation. This data would be collected from weather stations or other sources. The paper does not provide details on the specific dataset or its source. It primarily focuses on the methodology of using LSTM neural networks for weather prediction and the effectiveness of combining them with filtering techniques The paper proposes the use of Long Short Term Memory (LSTM) neural networks combined with Gaussian and Median filtering for weather prediction. The combination of LSTM and filtering techniques resulted in better accuracy in long-range weather prediction. The LSTM model was able to store key data and remember it for the long term using gates, allowing for more informed pattern formation. The use of Gaussian and Median filtering further optimized the models predictions. However, the paper does not provide specific quantitative results or performance metrics for the weather prediction model

E. Multidimensional time series weather prediction using long short-term memory neural network

Another study was conducted in 2021 by M. U. Agada et al. [5] where multidimensional time series weather prediction was proposed using a long short-term memory neural network. The research offers a Long Short-Term Memory (LSTM) neural network model for weather prediction, addressing the shortcomings of existing systems and emphasizing the value of accurate forecasts in a variety of industries. The model is trained and validated using meteorological data from four Nigerian cities, and its performance for daily and weekly forecasts based on selected multivariate weather factors is examined. The LSTM model is trained using the weather variables as input and the neuron in the LSTM network architectures hidden layers. The models performance is assessed for daily and weekly forecasts based on selected multivariate weather variables. The models performance is compared to existing machine learning architectures. For Mean Square Error (MSE), the proposed LSTM neural network model performed best for short-term forecasts (values ranging from 20.10% to 79.90%) compared to medium-term forecasts (values ranging from 26.94% to 73.06%). The models performance differed throughout Nigerias four cities, with Bauchi, Calabar, and Ikeja producing better daily forecasts due to greater stability in meteorological variables, while Minna produced the poorest. Due to the relative unpredictability of the formers weather variables, Ikeja City had the poorest weekly forecast outcomes, while Bauchi City had the best. The study discovered that the relative stability of the weather variable dispersed across time influences the suggested models learning capabilities

F. emperature prediction using time series time-delay neural networks

A temperature prediction model that covers the city of Agadir, Morocco proposed by Anas Kabbori et al. [6]. They have used a time series Time-Delay Neural Network, a type of dynamic neural network. They have considered the availability of data for the previous month to predict the temperature values for the next month. Their proposed model has 3 layers input layer, one hidden layer and an output layer. The activation function used with the hidden layer neurons is the hyperbolic tangent function and identity function for the output neuron. The network training used Backpropagation Through Time (BPTT) in epochwise mode. The training uses the LevenbergMarquardt backpropagation algorithm. The training data was gathered from the Meteorological station located in Agadir Airport and the data represents temperature values through the station on a 30 min basis 24 hours and 7 days a week. The data set for the first 28 days is used to train the proposed network, while the data set for the last two days is used to test the trained network. The performance of the network has been tested with MSE, training regression, Error autocorrelation, time-series response, and error histogram. Taking the last 48 hours of June 2019 as an example gave them a Mean Squared Error (MSE), between the actual response and the target for the testing data of a value of 0.4149. The computed value of The correlation coefficient using the testing data is about 0.99. They have found their best training 4 performance at epoch 1000 which is 0.17215

G. Climate change projections of maximum temperature in the premonsoon season in Bangladesh using statistical downscaling of global climate models

M. Bazlur Rashid et al. [7] studied on Global Climate Models (GCMs) where a statistical downscaling approach was applied to produce future climate projections for maximum temperatures during the pre-monsoon season (March-May) in Bangladesh for the 21st century. The analysis used in-situ temperature data from the Bangladesh Meteorological Department, which had recently been digitized. The study compared projected maximum pre-monsoon temperatures in Bangladesh to a reference period of 1981-2010. In this study, Global Climate Models (GCMs) were used, and a statistical downscaling approach was applied to produce future climate projections for maximum temperatures during the premonsoon season (March-May) in Bangladesh for the 21st century. The analysis used in-situ temperature data from the Bangladesh Meteorological Department, which had recently been digitized. The study compared projected maximum pre-monsoon temperatures in Bangladesh to a reference period of 1981-2010. The projections indicated temperature increases in the near future (2021-2050) and the far future (2071-2100) under different emission scenarios. The empirical-statistical downscaling approach used in this study involved deriving statistical relationships between the mean daily maximum temperature over the pre-monsoon season from station-based observations in the period 19812019 and the large-scale mean temperature patterns as represented by the common EOFs of the ERA5 reanalysis and GCM simulations. The GCM data (one simulation at a time, using the full period of available data 18502100) was combined with ERA5 reanalysis data for the period 19792019 along the time axis.EOF analysis was subsequently applied to the combined dataset.

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