

A Review on Weather Forecasting using Machine Learning and Deep Learning Techniques

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Abstract: Weather plays a crucial role in everyone's life. Accurate weather information is necessary to plan our day-to-day activities. Appropriate weather forecasting is important as it is to protect ourselves as well as our property. The primary aim of this study is to review different Machine Learning and Deep Learning techniques used in weather forecasting. Machine Learning is the automated process in which models learn by themselves, identify patterns and make decision. This review indicates that Machine Learning and Deep Learning techniques can help us to forecast weather based on input features such as temperature, humidity, Rainfall, Air Pressure and so on.

Keywords: Machine Learning, Deep Learning, Weather Forecasting, ANN, MLP

I. INTRODUCTION

The weather is the reflection state of the atmosphere around us.[1] The weather is a part of natural phenomenon that maintains equilibrium in the atmosphere. The temperature, humidity, wind speed, Rainfall, Evaporation, Air Pressure, Vapour Pressure, Sunshine duration, Sea Level, Visibility etc. are some of the elements of the weather.

Weather forecasting is an important research problem due to its effect in our day-to-day life. It is an essential approach to avoid harmful climatic conditions. Weather prediction plays a significant role in many components in decision making related to many fields such as agriculture, business, tourism, energy management, human and animal health etc.[2]

Machine Learning and Deep Learning, the branches of Artificial Intelligence focusing on learning and prediction provides a practical approach of prediction based on several features. A feature is nothing but the describing properties of an individual thing. The performance of ML model is measured by performance metric. These models provide sharp accuracy on deriving features using meteorological dataset.

This objective of this paper is to provide an overview of the different Machine Learning and Deep Learning techniques that have been used in weather forecasting.

II. LITERATURE REVIEW

[1] had predicted Rainfall using weather parameters like Low Temperature, High Temperature, Humidity and Wind Speed using Hybrid Machine Learning techniques such as MLP (Multi-Layer Perceptron) based PSO (Particle Swarm Optimization) and MLP (Multi-Layer Perceptron) based LM(Levenberg-Marquardt) techniques. The MLP based PSO shown more accuracy with RMSE=0.14 than MLP based LM.

Rainfall and Temperature Prediction was performed by [2] using Rainfall and Temperature dataset. It used ML Techniques such as Support Vector Regression (SVR) and Artificial Neural Networks (ANN). The results showed that SVR outperformed the ANN in rainfall prediction.

[3] had predicted Next day weather based on Maximum Temperature, Minimum Temperature, Evaporation, Humidity and Wind Speed as weather parameters using Linear Regression and Deep Neural Network Regressor. It was found that the DNN Regressor showed more accuracy than LR.

[4] had predicted Rainfall based on several meteorological parameters using Machine Learning and Deep Learning techniques such as ARIMA Model, Artificial Neural Network, Support Vector Machine, Multilayer Perceptron (MLP) Model and Auto-Encoders. It was found that the proposed methodology performed well.

[5] had predicted Temperature, Humidity and Pressure in the Next 24 Hours based on weather parameters such as Temperature, Humidity and Air Pressure using Long Short-Term Memory (LSTM) Model and Multilayer Perceptron

(MLP) Model. It was found that the proposed models were good at prediction, MAE of LSTM = 1.056 and MAE of MLP = 0.7731.

Rainfall Prediction was done by [6] using Rainfall measurement attributes including individual months, annual and combination of 3 consecutive months for 36 sub divisions as the input parameters. The Machine Learning techniques such as Multiple Linear Regression, Support Vector Regression, Lasso Regression was applied on the dataset. Principal Component Analysis technique was applied for feature reduction. It was found that Support Vector Regression outperformed the Multiple Linear Regression and Lasso.

[7] had predicted Rainfall based on weather parameters such as Rain, Relative Humidity, Vapour Pressure, Sunshine Duration, Cloud Amount and Visibility. Several Machine Learning Techniques were used in this domain. KMeans clustering and Hierarchical Clustering were used for weather patterns clusters finding. Linear Regression was used to predict rain based on sky visibility. Multiple Linear Regression was used to predict rain based on cloud amount, visibility in sky, relative humidity and sun shine duration. Multivariate Multiple Linear Regression was used to predict rain and cloud visibility based on atmospheric temperature, cloud amount in sky and relative humidity. Among all this, Multivariate Multiple Linear Regression was performed well in prediction of rain. LR and MLR was also close enough.

[8] had predicted Rainfall based on hourly meteorological data such as Pressure, Temperature, Humidity, Wind Speed, Wind direction, Sea Level and Rainfall using Deep Learning Techniques Echo state network (ESN) and Deep Echo state network (DeepESN). The accuracy of predicted rainfall by using the DeepESN was improved compared with those by using ESN, the BPN and the SVR.

Prediction of Rainfall was done by [9] with the help of weather parameters such as Temperature, Humidity and Pressure. Random Forest Classification algorithm was used and 87.90% of accuracy was achieved by this technique.

[10] had predicted Maximum and Minimum Temperatures of the Next Day and Mean Temperature of the Next Day based on weather parameters such as Pressure, Humidity, Rainfall, Temperature, Dust Particles and Light by using Multiple Linear Regression Model. The 94% accuracy achieved for next day minimum temperature. The 93% accuracy achieved for next day maximum temperature. The 95% accuracy achieved for next day Mean temperature.

[11] had predicted Rainfall, Humidity, Wind Speed, High Temperature and Low Temperature using weather parameters such as Wind Speed, Humidity, Temperature and Rainfall. It used several ML Techniques like Support Vector Regression (SVR), Linear Regression, Bayesian Ridge, Gradient Boosting (GB), Extreme Gradient Boosting (XGBoost), Category Boosting (CatBoost), Adaptive Boosting (AdaBoost), k-Nearest Neighbors (KNN) and Decision Tree Regressor (DTR). It was found that, ML-based models are more accurate than conventional methods. However, it can be seen that DTR and CatBoost methods were almost equivalent but adaptability of DTR was more for nonlinear data.

Weather Prediction was performed by [12] using ENSO Dataset and Weather Dataset. It used Deep Learning Techniques like Recurrence Neural Network (RNN), Conditional Restricted Boltzmann Machine (CRBM), and Convolutional Network (CN) models. The results showed that Recurrent NN using heuristically optimization method for rainfall prediction based on weather dataset comprises of ENSO variables.

The below table tabulates the various Machine learning and Deep Learning techniques used for weather prediction with different set of weather parameters.

TABLE I

References	Parameters	Technique	Result	Prediction
H.Abdel-Kader et al.[1]	Low Temperature, High Temperature, Humidity, And Wind Speed	MLP (Multi-Layer Perceptron) based PSO (Particle Swarm Optimization), MLP (Multi-Layer Perceptron) based LM(Levenberg-Marquardt)	MLP based PSO shown more accuracy (RMSE=0.14) than MLP based LM.	Rainfall Prediction
R.I.Rasel et al. [2]	Rainfall dataset Temperature dataset	Support Vector Regression (SVR) and Artificial Neural Networks (ANN)	SVR outperformed the ANN in rainfall prediction	Rainfall and Temperature Prediction
B.S. Panda et al. [3]	Maximum Temperature, Minimum Temperature, Evaporation, Humidity and Wind Speed	Linear Regression, Deep Neural Network Regressor	The DNN Regressor shown more accuracy than LR.	Next day weather
C.Z. Basha et al. [4]	Meteorological Data	ARIMA Model, Artificial Neural Network, Support Vector Machine, Multilayer Perceptron (MLP) Model, Auto-Encoders	The proposed methodology had outperformed.	Rainfall Prediction
Z.Q. Huang et al. [5]	Temperature, Humidity, And Air Pressure	Long Short-Term Memory (LSTM) Model and The Multilayer Perceptron (MLP) Model	Proposed models were good at prediction. MAE (LSTM) = 1.056 and MAE (MLP) = 0.7731	Temperature, humidity, Pressure in the Next 24 Hours
M. Mohammed et al. [6]	Rainfall measurement attributes including individual months, annual and combination of 3 consecutive months for 36 sub divisions.	Multiple Linear Regression Support Vector Regression Lasso Regression Principal Component Analysis- for feature reduction	SVR outperformed the MLR and Lasso.	Rainfall Prediction

<p>A.M. Suresha[7]</p>	<p>Rain, Relative Humidity, Vapour Pressure, Sunshine Duration, Cloud Amount, Visibility</p>	<p>Kmeans clustering and Hierarchical Clustering - weather patterns clusters finding, Linear Regression – to predict rain based on sky visibility Multiple Linear Regression – to predict rain based on cloud amount, visibility in sky, relative humidity and sun shine duration. Multivariate Multiple Linear Regression – to predict rain and cloud visibility based on atmospheric temperature, cloud amount in sky and relative humidity.</p>	<p>Multivariate Multiple Linear Regression was performed well in prediction of rain. LR and MLR was also close enough.</p>	<p>Rainfall Prediction</p>
<p>M.H.Yen et al. [8]</p>	<p>Hourly meteorological data (Pressure, Temperature, Humidity, Wind Speed, Wind direction, Sea Level, Rainfall)</p>	<p>Echo state network (ESN) and Deep Echo state network (DeepESN)</p>	<p>The accuracy of predicted rainfall by using the DeepESN was improved compared with those by using ESN, the BPN and the SVR</p>	<p>Rainfall Prediction</p>
<p>N. Singh et al. [9]</p>	<p>Temperature, Humidity and Pressure</p>	<p>Random Forest Classification</p>	<p>Accuracy of 87.90% was achieved.</p>	<p>Rainfall Prediction</p>
<p>A. Parashar [10]</p>	<p>Pressure, Humidity, Rainfall, Temperature, Dust Particles And Light</p>	<p>Multiple Linear Regression Model</p>	<p>94% accuracy achieved for next day minimum temperature. 93% accuracy achieved for next day maximum temperature. 95% accuracy achieved for next day Mean temperature.</p>	<p>Maximum and Minimum Temperatures of the Next Day Mean Temperature of the Next Day</p>
<p>A. Mahabub [11]</p>	<p>Wind Speed, Humidity, Temperature And Rainfall</p>	<p>Support Vector Regression (SVR), Linear Regression, Bayesian Ridge, Gradient Boosting (GB), Extreme Gradient Boosting (XGBoost), Category Boosting (CatBoost), Adaptive Boosting (AdaBoost), k-Nearest Neighbors (KNN) and Decision Tree Regressor</p>	<p>ML-based models are more accurate than conventional methods. It can be said that DTR and CatBoost methods were almost equivalent but adaptability of DTR was more for nonlinear data.</p>	<p>Rainfall Prediction Humidity Prediction Wind Speed Prediction High Temperature prediction Low Temperature prediction</p>

		(DTR)		
A. G. Salman et al. [12]	Wind, Oscillation Index, Sea Surface Temperature and Outgoing Long Wave Radiation (ENSO Dataset) Mean Temperature, Max Temperature, Minimum Temperature, Precipitation Temperature, Relative Humidity, Mean Sea Level Pressure, Mean Station Pressure, Visibility, Average Win, Maximum Wind, Wind and Rainfall (Weather Dataset)	Recurrence Neural Network (RNN), Conditional Restricted Boltzmann Machine (CRBM), and Convolutional Network (CN) models.	Recurrent NN using heuristically optimization method for rainfall prediction based on weather dataset comprises of ENSO variables	Weather Prediction

III. CONCLUSION

Weather Forecasting is a challenging task but very important research problem. Because it is related to our day-to-day life. Machine Learning and Deep Learning techniques can help us to forecast weather based on several input features. Also IoT techniques can significantly combine with Machine Learning and Deep Learning to produce better result. Accuracy in prediction is strongly dependent on the time period and location of weather station. The results showed that hybrid ML techniques and Deep Learning strategies can achieve better accuracy.

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