Machine learning based smart weather prediction

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ABSTRACT

Weather forecasting refers to the prediction of atmospheric conditions depending on a given time and location. Weather prediction is essential and it plays a significant role in many sectors namely energy and utililities, marine transportation, aviation, agriculture and forestry to a greater extent. Accurate weather forecast mechanism help the farmers for suitable planning of farming operations that will prevent crop losses. In this work, the weather parameters namely precipitation, relative humidity, wind speed and solar radiation were predicted for few Indian locations using the conventional temperature based empirical models and machine learning algorithms such as linear regression, support-vector machine (SVM) and decision tree. Forecasting of weather parameters, on which agriculture depends, will increase the overall yield and it helps farmers and agricultural-based businesses to plan better. From the current results, it is observed that machine learning (ML) based methods had a better prediction results than the physics based conventional models for weather forecasting with mean square error of 0.1397 and correlation coefficient of 0.9259. The objective of this work is to arrive at an optimized end result and a better weather prediction using the Machine learning models with lesser computational effort.

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1. INTRODUCTION

Agriculture and farming are chiefly dependent on various weather parameters. Weather prediction is necessary to find out future climate changesand it plays a significant role in many sectors namely renewable energy, transportation, manufacturing, supply chain management, agriculture and forestry. Accurate weather forecasting helps farmers for suitable planning of farming operations. So, accurate weather prediction is necessary for the farmers to get the maximum yield in agriculture and also to prevent the crop wastage. For country like India, it is difficult to predict and forecast the weather parametersaccurately for various seasons and climates due to the complexity of weather events. In earlier days, there is no better understanding of weather forecasting due to the limited network of weather stations. Sometimes losses may occur in the agriculture crop due to the false prediction of waether. India has witnessed an increase in the mean temperature since the mid of 20th century. Also man-made climate change is likely to continue apace during 21st century. To improve the accuracy of future climate predictions, it is important to develop various approaches for improving the knowledge of earth atmosphere system. Researchers have developed different models to forecast the weather parameters commonly using random numbers and they are relatively similar to the climate data. Various climate models such as mathematical model [1], empirical model [2], ARMA [3], artificial

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intelligence-based models [4]-[7], fuzzy and ANFIS [8], [9], datamining and internet of things (IoT) based forecasting models [10], [11] are reported in the literatures. Recently machine learning (ML) [12]-[18], deep learning [19] and hybrid models [20], [21] are widely applied for weather forecasting. In this research work, theweather prediction model is developed using machine learning algorithms like support-vector machine (SVM), linear regression and decision tree. The proposed method usesmeteorological data collected from few selected regions within India to predict the weather parameters.

2. OVERVIEW OF MACHINE LEARNING BASED WEATHER PREDICTION MODELS

Machine learning algorithms are categorized into twoclassifications namely supervised learning and unsupervised learning. The clustering algorithms come under unsupervised machine learning category. Ahmed and Mohamed [22] used linear regression machine learning model to estimate the rate of precipitation (PRCP). Srivastava *et al.* [23] predicted monthly precipitation using various ML algorithms such as Support vector machine (SVM), linear regression, artificial neural network (ANN) using back propagation and long short-term memory network (LSTM) for early warning oflandslide occurrence. Devi *et al.* [24] usedback propagation neural network to provide arly warning of landslideswith combination of meansquare error and correlation coefficient as the performance metrics. Sakthivel *et al.* [25] used intense neural network mining with combination of mean square error (MSE) and root mean square error (RMSE) to achieve preprocessed rainfall data with reverse mapping values. Basha *et al.* [26] utilized autoregressive integrated moving average (ARIMA) model, artificial neural network, support vector machine with combination of MSE and RMSE as the metrics to predictrainfall for agricultural related applications. Babu and Arulmozhivarman [27] applied ANN models for effective wind speed forecasting. Table 1 can be seen in *appendix*, presents the literature survey of weather prediction models along with the methodology and the performance metrices.

3. RESEARCH METHODS

In this section, the methodology and the results of the weather prediction models are discussed. Various weather parameters namelyminimum temperature (°C), maximum temperature (°C), mean temperature (°C), relative humidity (%), wind speed (m/s) and solar radiation data (w/m²) are used to build the machine learning models. Decision tree and linear regression-based ML models are used to predict the weather parameters namely precipitation, wind speed, relative humidity and solar radiation which play a vital role in agricultural field. In addition to the ML models, temperature based empirical models namely Hargreaves and Samani and Bristow and Campbell models are also utilized to predict solar radiation for selected Indian locations namely Trivandrum, Chennai and New Delhi and precipitation of wind speed and percentage relative humidity was done for Bangalore and New Delhi.

3.1. Collection of data

The data set for building the machine learning model were taken from Indian Meteorological Department, Pune and from AQUASTAT website. The Dataset was prepared by combining the monthly data of Indian locations namely New Delhi, Bangalore, Hyderabad, Trivandrum and Mumbai and eight locations within the state of Tamilnadu namely Chennai, Coimbatore, Kodaikanal, Madurai, Ooty, Pondichery, Ramanathapuram, Salem and Tiruchirappalli. The input parameters for predicting the Precipitation (mm/d) areminimum temperature (°C), maximum temperature (°C), mean temperature (°C), relative humidity and wind speed (m/s) for wind speed prediction relative humidity is excluded. The research indicated that all the above-mentioned input parameters have significant importance in the prediction.

All the input parameters were put together in a comma separated values (CSV) file for forecasting of wind speed. The complete dataset is divided into three sets such as training set, validation set and testing data set. It is further processed with the help of two empirical models and ML models. Spyder an open-source cross-platform integrated development environment (IDE) for scientific programming in the Python languageis used for developing the computer codes for empirical and ML models. Further, the machine learning models were validated using the experimental IMD testing dataset. Table 2 presents the input parameters considered for the prediction of weather parameters.

3.2. Data splitting

The complete dataset is divided into three sets namely training, teasting and validation data set; i) Training Set: The training part of dataset will be of 70 percentage of total dataset; ii) Test Set: The validation part of the data set will be of 30 percentage of total dataset; iii) Validationset: This set can be realtime data or recorded data from IMD, Pune by which the model's final performance is evaluated.

3.3. Model selection

Linear regression and decision tree algorithm were used for the prediction of precipitation, relative humidity, wind speed and solar radiation. Also, the temperature based empirical model namely the Hargreaves and Samani and Bristow and Campbell models are used to estimate the solar radiation. The decision tree algorithm was used in the prediction of wind speed.

Month	Maximun Temperature	Minimum Temperature	Relative Humidity	Surface pressure
number	(°C)	(°C)	(%)	(kPa)
1	20.64	7.28	41.28	99.13
2	25.31	11.00	38.25	98.91
3	31.18	15.90	27.27	98.58
4	37.62	21.99	18.96	98.15
5	40.50	26.30	20.99	97.69
6	40.12	28.55	31.41	97.34
7	36.46	28.00	56.27	97.33
8	34.38	26.72	70.01	97.58
9	33.80	24.60	67.58	97.98
10	33.09	19.00	46.01	98.60
11	28.60	13.07	38.49	98.92
12	20.64	7.28	41.28	99.13

Table 2. Input parameters considered for the prediction of wind speed

3.3.1. Linear regression

Linear regression algorithm represent a linear relationship between a dependent and independent variables. Since linear regression shows the linear relationship, it will value the dependent variable in response to the changes in value of the independent variable. Equation for linear regression (1):

$$y = a_0 + a_1 x + \varepsilon \tag{1}$$

- Positive linear relation: The linear relation is said to be positive when dependent variable increases on an axis (y) so does the independent variable on an axis (x).
- Negative linear relation: The linear relation is said to be negative when dependent variable decreases on an axis (y) as the independent variable getting decreased on an axis (x). Figure 1. gives the pictorial representation of the positive and negative linear relation.



Hargreaves and Samani Model [28]

$$\frac{H}{H_0} = a \,\Delta T^{0.5} \tag{2}$$

Figure 1. Positive and negative linear relation

Bristow and Campbell model [29]

$$\frac{H}{H_0} = a(1 - exp(-b\Delta T)^c) \tag{3}$$

where ΔT is the difference between the maximum and minimum temperature. *a*, *b* and *c* are the empirical constants determined by using statistical regression technique.

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3.3.2. Decision tree

Decision Tree is one of the most popularly used, workable approaches to supervised machine learning. A decision tree model can be used in regression as well as a classification problem [30]. It works by breaking the data up in a tree like structure into smaller and smaller subsets. It is a peculiar type of probability tree that allows us to make a decision about our process.

4. RESULTS AND DISCUSSION

The weather parameters can be estimated with better accuracy using ML based models in comparision with empirical models. Figure 2 shows the comparision between the estimated and measured solar radiation, IMD, Pune values for the location New Delhi using the temperatre based empirical model namely the Hargreaves and Samani and Bristow and Campbell models. Figure 3 shows the comparision between the estimated and measured solar radiation, IMD, Pune values for the location Trivandrum and Chennai using the ML model.



Figure 2. Soalr radiation estimation using Hargreaves and Samani model and Bristow and Campbell model



Figure 3. Solar radiation estimation using decision tree ML model

Figure 4 shows the predicted weather parameters namely % relative humidity and wind speed using ML models for the locations Bangalore and New Delhi. The performance metrics used to validate the proposed ML models are mean squared error (MSE) and the correlation coefficient. MSE which is the mean of squared error occurred between the estimated values and real recorded values. A low error value is desired to get the accurate model. For better prediction, correlation coefficient should approach to unity as close as possible. From the performance metrics Table 3, it is concluded that the weather parameters can be predicted with better accuracy using ML based models in comparision with empirical models.



Figure 4. Predicted Weather parameters namely % relative humidity and wind speed using ML models

Table 3. Performance metrics						
S. No Hargreaves and Samani		Bristow and Campbell	Decision tree regression ML			
	model	model	model			
MSE	1.5272	1.5423	0.1397			
R-Correlation coefficient	0.8921	0.8874	0.9259			

5. CONCLUSION

In the presented research work, weather parameters namely rainfall, wind speed, solar radiation and relative humidiy are predicted using the machine learning algorithms such as linear regression and decision tree model. Also the solar radiation for few selected Indian locations were estimated using the conventional temperature based empirical models namely the Hargreaves and samani and Bristow and Campbell model. The empirical and machine learning models are validated using the recorded experimental values obtained from IMD, Pune. From the results, it is proved that ML based results models performed better in comparision with empirical modelswith correlation coefficient 'R' value of 0.9259 and MSE of 0.1397. Thus the research work has arrived at an optimized end result with a better weather prediction with lesser computational effort.

APPENDIX

S. No Index Research Area Input Parameters Methods and Performance Metrics 1 Prediction of Wind Speed using Artificial Neural Network model [5] Temperature, Carb humidity, Air pressure. Methods and Performance Metrics 2 Prediction of Wind Speed Verse Temperature, Carb humidity, Air pressure. Methods and Performance Metrics 3 Artificial neural network model [5] Temperature, Carb humidity, Air pressure. Temperature, Carb humidity, Air pressure. 3 Artificial neural network (ANN). Temperature, Carb humidity, Air pressure. Temperature, Carb humidity, Air pressure. Methods and Performance Metrics 4 Wind Speed Prediction- Saisu Muhammad Lawan (ELTA) 2018. [9] Pressure forecashing model [10] Temperature, Harink Humidity, Minimum and maximum Temperature, Carb humidity mediciton Rainfall Prediction using Machine Learning, Grace and Sugany [13] Machine Learning humidity for prediction real mathematical model-Saba et al. [20] Minimum and maximum model-Saba et al. [20] Maximum and minimum model-Saba et al. [20] Maximum and minimum memperature, Wet temperature, Wet temperature, Minimum temperature, Wet temperature, Minimum temperature, Maximuity, Pressure Multiple linear prediction reagension method model 11 A deep hybrid model for weather forecasting-Adity et al. [21] Temperature, Wet temperature, Minimum temperature, Wet temperature, Mini		Table 1. Enterature	survey of weather prediction mo	ucis
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Mean Absolute Error-0.022				RBFN-Mean Square Error-0.009
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Table 1. Literature survey of weather prediction models

REFERENCES

- M. Rajasekaran, A. I. Selvakumar, and E. Rajasekaran, "Review on mathematical models for the prediction of solar radiation," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 15, no. 1, p. 56, Jul. 2019, doi: 10.11591/ijeecs.v15.i1.pp56-61.
- [2] M. A. S. Bhuiyan, A. S. Bhuiyan, M. J. A. Patwary, S. Akter, and M. M. Alam, "Emperical Computation of Solar Radiation and Determination of Regression Coefficients for Khulna City," *TELKOMNIKA Indonesian Journal of Electrical Engineering*, vol. 12, no. 12, Dec. 2014, doi: 10.11591/telkomnika.v12i12.6696.

- [3] E. Toth, A. Brath, and A. Montanari, "Comparison of short-term rainfall prediction models for real-time flood forecasting," *Journal of Hydrology*, vol. 239, no. 1–4, pp. 132–147, 2000, doi: 10.1016/S0022-1694(00)00344-9.
- [4] R. Meenal, A. I. Selvakumar, P. A. Michael, and E. Rajasekaran, "Sensitivity analysis based artificial neural network approach for global solar radiation prediction in India," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 20, no. 1, p. 31, Oct. 2020, doi: 10.11591/ijeecs.v20.i1.pp31-38.
- I. Marović, I. Sušanj, and N. Ožanić, "Development of ANN model for wind speed prediction as a support for early warning system," *Complexity*, vol. 2017, pp. 1–10, 2017, doi: 10.1155/2017/3418145.
- [6] A. Kala and S. G. Vaidyanathan, "Prediction of rainfall using artificial neural network," in 2018 International Conference on Inventive Research in Computing Applications (ICIRCA), Jul. 2018, pp. 339–342, doi: 10.1109/ICIRCA.2018.8597421.
- [7] T. R. V. Anandharajan, G. A. Hariharan, K. K. Vignajeth, R. Jijendiran, and Kushmita, "Weather monitoring using artificial intelligence," in 2016 2nd International Conference on Computational Intelligence and Networks (CINE), Jan. 2016, vol. 2016-Janua, pp. 106–111, doi: 10.1109/CINE.2016.26.
- [8] N. Z. M. Safar, A. A. Ramli, H. Mahdin, D. Ndzi, and K. M. N. K. Khalif, "Rain prediction using fuzzy rule based system in North-West malaysia," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 14, no. 3, p. 1564, Jun. 2019, doi: 10.11591/ijeecs.v14.i3.pp1564-1573.
- [9] S. M. Lawan, W. A. W. Z. Abidin, and U. Abubakar, "Wind speed prediction in non-monitored areas based on topographic radial basis neural network (T-RBNN)," *IOP Conference Series: Earth and Environmental Science*, vol. 168, no. 1, p. 012012, Jun. 2018, doi: 10.1088/1755-1315/168/1/012012.
- [10] R. Kumar and R. Khatri, "A weather forecasting model using the data mining technique," International Journal of Computer Applications, vol. 139, no. 14, pp. 4–12, Apr. 2016, doi: 10.5120/ijca2016908900.
- [11] A. Kulkarni and D. Mukhopadhyay, "Internet of things based weather forecast monitoring system," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 9, no. 3, p. 555, Mar. 2018, doi: 10.11591/ijeecs.v9.i3.pp555-557.
- [12] R. Meenal, P. A. Michael, D. Pamela, and E. Rajasekaran, "Weather prediction using random forest machine learning model," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 22, no. 2, pp. 1208–1215, 2021, doi: 10.11591/ijeecs.v22.i2.pp1208-1215.
- [13] R. K. Grace and B. Suganya, "Machine learning based rainfall prediction," in 2020 6th International Conference on Advanced Computing and Communication Systems (ICACCS), Mar. 2020, pp. 227–229, doi: 10.1109/ICACCS48705.2020.9074233.
- [14] C. Thirumalai, K. S. Harsha, M. L. Deepak, and K. C. Krishna, "Heuristic prediction of rainfall using machine learning techniques," in 2017 International Conference on Trends in Electronics and Informatics (ICEI), May 2017, vol. 2018-Janua, pp. 1114–1117, doi: 10.1109/ICOEI.2017.8300884.
- [15] Y. Radhika and M. Shashi, "Atmospheric temperature prediction using support vector machines," International Journal of Computer Theory and Engineering, pp. 55–58, 2009, doi: 10.7763/ijcte.2009.v1.9.
- [16] B. Bochenek and Z. Ustrnul, "Machine learning in weather prediction and climate analyses—applications and perspectives," *Atmosphere*, vol. 13, no. 2, p. 180, Jan. 2022, doi: 10.3390/atmos13020180.
- [17] S. Gebretinsae, M. W. Ahmad, G. K. T, N. Sreenivas, and B. Yirga, "Machine learning-based intelligent weather monitoring and predicting system," *International Journal of Engineering Trends and Technology*, vol. 70, no. 4, pp. 152–163, Apr. 2022, doi: 10.14445/22315381/IJETT-V70I4P213.
- [18] R. Meenal et al., "Weather forecasting for renewable energy system: a review," Archives of Computational Methods in Engineering, vol. 29, no. 5, pp. 2875–2891, Aug. 2022, doi: 10.1007/s11831-021-09695-3.
- [19] S. M. R. K. Al-Jumur, S. W. Kareem, and R. Z. Yousif, "Predicting temperature of Erbil City applying deep learning and neural network," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 22, no. 2, p. 944, May 2021, doi: 10.11591/ijeecs.v22.i2.pp944-952.
- [20] T. Saba, A. Rehman, and J. S. AlGhamdi, "Weather forecasting based on hybrid neural model," *Applied Water Science*, vol. 7, no. 7, pp. 3869–3874, Nov. 2017, doi: 10.1007/s13201-017-0538-0.
- [21] A. Grover, A. Kapoor, and E. Horvitz, "A deep hybrid model for weather forecasting," in *Proceedings of the ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, Aug. 2015, vol. 2015-August, pp. 379–386, doi: 10.1145/2783258.2783275.
- [22] H. A. Y. Ahmed and S. W. A. Mohamed, "Rainfall prediction using multiple linear regressions model," in 2020 International Conference on Computer, Control, Electrical, and Electronics Engineering (ICCCEEE), Feb. 2021, pp. 1–5, doi: 10.1109/ICCCEEE49695.2021.9429650.
- [23] S. Srivastava, N. Anand, S. Sharma, S. Dhar, and L. K. Sinha, "Monthly rainfall prediction using various machine learning algorithms for early warning of landslide occurrence," in 2020 International Conference for Emerging Technology, INCET 2020, Jun. 2020, pp. 1–7, doi: 10.1109/INCET49848.2020.9154184.
- [24] S. R. Devi, C. Venkatesh, P. Agarwal, and P. Arulmozhivarman, "Daily rainfall forecasting using artificial neural networks for early warning of landslides," in 2014 International Conference on Advances in Computing, Communications and Informatics (ICACCI), Sep. 2014, pp. 2218–2224, doi: 10.1109/ICACCI.2014.6968566.
- [25] S. Sakthivel and G. Thailambal, "Effective procedure to predict rainfall conditions using hybrid machine learning strategies," *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, vol. 12, no. 6, pp. 209–216, Apr. 2021, doi: 10.17762/turcomat.v12i6.1291.
- [26] C. Z. Basha, N. Bhavana, P. Bhavya, and V. Sowmya, "Rainfall prediction using machine learning deep learning techniques," in Proceedings of the International Conference on Electronics and Sustainable Communication Systems, ICESC 2020, Jul. 2020, pp. 92–97, doi: 10.1109/ICESC48915.2020.9155896.
- [27] N. R. Babu and P. Arulmozhivarman, "Forecasting of wind speed using artificial neural networks," *International Review on Modelling and Simulations*, vol. 5, no. 5, pp. 2276–2280, 2012.
- [28] W. R. Hamon, "Estimating potential evapotranspiration," *Transactions of the American Society of Civil Engineers*, vol. 128, no. 1, pp. 324–338, Jan. 1963, doi: 10.1061/TACEAT.0008673.
- [29] K. L. Bristow and G. S. Campbell, "On the relationship between incoming solar radiation and daily maximum and minimum temperature," *Agricultural and Forest Meteorology*, vol. 31, no. 2, pp. 159–166, May 1984, doi: 10.1016/0168-1923(84)90017-0.
- [30] S. Lotfi, M. Ghasemzadeh, M. Mohsenzadeh, and M. Mirzarezaee, "Scalable decision tree based on fuzzy partitioning and an incremental approach," *International Journal of Electrical and Computer Engineering*, vol. 12, no. 4, pp. 4228–4234, Aug. 2022, doi: 10.11591/ijece.v12i4.pp4228-4234.

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