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Weather Forecast Using Time Series Analysis and Machine Learning

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ABSTRACT: The present study is undertaken to develop area specific weather forecasting models based on time series data for Pantnagar, Uttarakhand. The study was carried out by using time series secondary monthly weather data of 27 years (from 1981-82 to 2007-08). The trend analysis of weather parameters was done by Mann-Kendall test statistics. The methodologies adopted to forecast weather parameters were the winter's exponential smoothing model and Seasonal Autoregressive Integrated Moving Average (SARIMA). Comparative study has been carried out by using forecast error percentage and mean square error. This paper explores three machine learning models for weather prediction namely Support Vector Machine(SVM), Artificial Neural Network(ANN) and a Time Series based Recurrent Neural Network(RNN). It also discussed the steps followed to achieve results. RNN using time series along with a linear SVC and a five-layered neural network is used to predict the weather. The results of these models are analyzed and compared on the basis of Root Mean Squared Error between the predicted and actual values.

KEYWORDS: Machine learning, weather forecasting, Time series analysis, SARIMA

I. INTRODUCTION

Weather forecasting is the application of scientific techniques and technology to predict the conditions of the atmosphere at a certain location and time. Weather Forecasting in old time is carried out by hand, using changes in barometric pressure, current weather conditions, and sky condition or cloud cover, weather forecasting now relies on computer-based models that take many atmospheric factors into accounting now relies on computer-based models that take many atmospheric factors into account.

Agricultural businesses, associated government systems and farmers depending on agriculture for sustenance, may all be significantly responsive to fluctuations in climate, largely through the impacts of climate on production and associated management intervention. Agro-meteorologists have tough challenges ahead in understanding the impact of weather and climate on growth and yield of crops. The more concerted efforts are essential to realize the present day needs of the farmers by the agricultural community of the country and also meet the demands of the poorer section of the country. Weather forecasting is the application of science and technology to predict the state of the atmosphere.

For a long time, the researcher had attempted to establish a linear relationship between the input weather data attributes and the corresponding target attribute. But the discovery of nonlinearity within different attributes of weather data, the focus has shifted towards the nonlinear prediction of the weather. Weather forecasts are made by collecting quantitative data about the current state and previous trend of the atmosphere and using scientific understanding of atmospheric processes to predict how the atmosphere will evolve. The weather warning is important for the protection of life and property. Rain predictions can be used by farmers.

Weather prediction has seen a variety of approaches in recent years based on Genetic Algorithms and Neural networks but these fail to capture the complex relationships between various factors which affect weather. In the neural network

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approach, Kaur[2] and Maqsood[1] describes a model that predicts the hourly temperature, wind speed and relative humidity 24 hours ahead. The authors have made a comparison of Multilayer Perceptron Networks (MLP), Radial Basis Function Network (RBFN).

All these models do a good job in identifying the seasonal variations but fail in trend and random variations. A variety of time series models have also been developed[6] like Autoregression, Autoregressive Moving Average (ARMA), Autoregressive Integrated Moving Average (ARIMA) etc. but combining time series with the neural

Figure 1: Time Series Forecasting

network[7] is mostly unexplored. We found that RNN with time series performs better than the classical time series models.

II.LITERATURE REVIEW

The period 1901-1977 are used to investigate and understand the inter annual variability of the summer monsoon rainfall. Also Kumar et al., 2007 used an Artificial Intelligence approach to handle the highly nonlinear and complex behavior of the climatic variables for regional rainfall forecasting for Orissa, India on monthly and seasonal time scales. Gadgil et al., 2002, worked on forecasting of Indian summer monsoon and Asin 2005, introduced a statistical procedure for obtaining long-term local daily precipitation forecasts in a climate change scenario. Two major groups, at the India Meteorological Department and at the Indian Institute of Tropical Meteorology, have mainly dealt with the analysis of long term temperature and precipitation records. Most of the studies of temperature analysis dealt with the analysis of surface temperature records of some individual observatory stations in the country. However, very few studies have been made of surface temperature trends in the country as a whole (Hingane et al., 1985). The present paper described the area specific weather forecasting models based on time series data.

Future time and at a given location. In agriculture industry weather forecasting provides the opportunity to the farmers for enhancing input efficiency that enhances the chance for increasing productivity and reducing cost of production. Knowledge of seasonal climatic forecasts allows farmers to develop seasonal management strategies leading to potential improvements in productivity. It helps them in determining planting dates, irrigation needs, crop types, fertilization, and

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planting materials. Farmers can take many macro and micro level decisions within time and avoiding belated farm operations. Several studies of climate variability on both short and long time scales have been carried out in India and abroad to establish climate changes over India. Kripalani et al., 1996, studied monthly rainfall data for 14 stations over Bangladesh.
The Mann-Kendall test has two parameters that are of importance for trend detection: the significance level, which indicates the trend strength, and the slope estimate, which indicates the direction as well as the rate of change.

In order to analyze different machine learning techniques. We have collected data[3] from different airport weather station of India. This datasets include several attributes Air temperature at 2 metre height above the earth's surface, Atmospheric pressure at weather station level,Atmospheric pressure reduced to mean sea level, Relative humidity (%) at a height of 2 metres above the earth's surface, Mean wind direction at a height of 10-12 metres above the earth's surface, Total cloud cover, Horizontal visibility, Dew point temperature at a height of 2 metres above the earth's surface. This dataset contains data of previous 12 years 2006-2018. Data for some days are missing in this dataset but this can be compensated by the large size of the dataset.

Naveen L and Mohan HS [5]. From results, it is seen that the Wavelet based SVM and RBF NN utilizing HPSOGA gives remarkable execution productivity. In any case, any enhanced half breed approaches utilizing NN could be executed for achieving better outcomes. Bankert et al [6], tried to automate the estimation of various meteorological parameters using satellite data and machine learning techniques. Similar to the GOES cloud classification algorithm, a set of training data is used within a K-nearest neighbour algorithm to estimate the intensity of tropical cyclones as seen in SSM/I imagery. This training data consists of 942 images that are represented by selected characteristic features of the 85 GHz channel and an SSM/I-derived rain rate product. These features (from a total set of 101). Using available data from various sources, a best track maximum wind speed has been determined for each TC at a given time by either the Joint Typhoon Warning Center or the National Hurricane Center. This best track maximum wind speed is used as the ground truth.

III.METHODOLOGY OF PROPOSED SURVEY

Research Methodology is the orderly, theoretical analysis of the techniques applied to a field of study. It is a systematic way to resolve a problem. It is a science of studying how research is to be carried out. Basically, the actions by which researchers do their work of describing, explaining and predicting phenomena are called research methodology. It is also defined as the study of methods by which knowledge is gained. Its goal is to provide the work plan of research. In this chapter the main goal is to study and analyze some indispensible machine learning models and statistical approaches used for forecasting purpose. Some important methods that are considered in this study are Simple Moving Average, Exponential Moving Average, Naïve Bayesian Regression, K Nearest Neighbour, and Artificial Neural Network. These methods are extensively studied and then a computer program is proposed for each technique. The details of each method is as under.

It is a sort of mathematical convolution. It is a Simple short-run forecasting tools based on some underlying pattern to the data. A moving average can be calculated for the purpose of smoothing the original series, or to obtain a forecast. Simply put Moving Averages are a math calculation that averages out a series of numeric values. A moving average series can be calculated for any time series. In finance it is most often applied to stock and derivative prices, percentage returns etc. Moving averages are used to track the current trend. Simple moving average is purely a statistical method used for forecasting purpose.

Data preprocessing is a data mining technique that involves transforming raw data into a usable format. The dataset contains some missing values. In order to train the model on this dataset, we used the following preprocessing techniques.

No real-world dataset is complete so we have to fill empty values and columns, texts need to mapped with numbers before feeding dataset to different models. First,we assign different numbers to different wind direction and map it to wind directions columns. All columns have numerical values For columns dew point and rain we fill not available rows with 0 representing no dew and rain respective.

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The relationship between various columns of the weather data is considered and their covariance matrix is generated showing linear dependence between different columns. Columns with high linear dependence do no provide important information in prediction thus removed from the dataset.

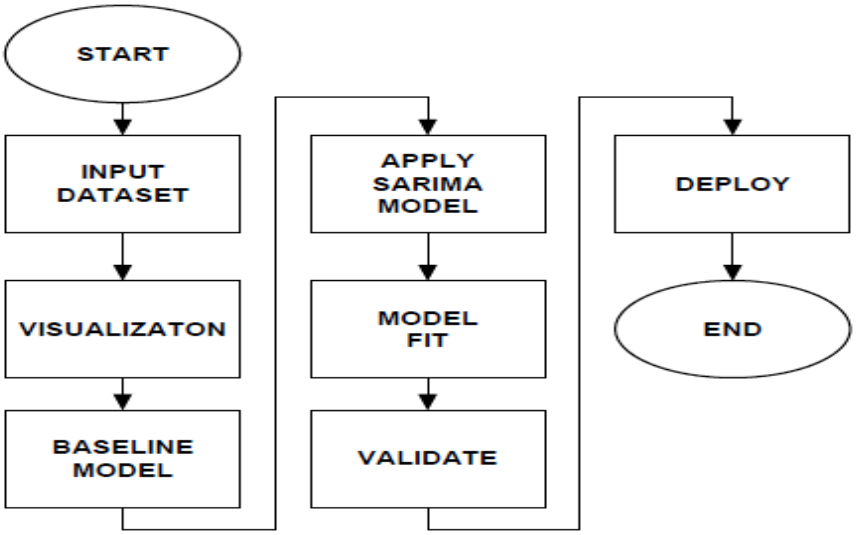

Figure 2:Flow chart

IV. RESULTS AND DISCUSSION

Identification of trend in different weather parameters

In this section monthly trends in four weather parameters, viz., monthly maximum temperature, monthly minimum temperature, monthly average temperature and monthly total rainfall over the years (1981 to 2008) were examined. Significance of trends was tested using MannKendall's test.

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Forecasting of weather parameters using winter's exponential smoothing method

The obtained results using Winter's model for various weather parameters are presented under different sub heads.

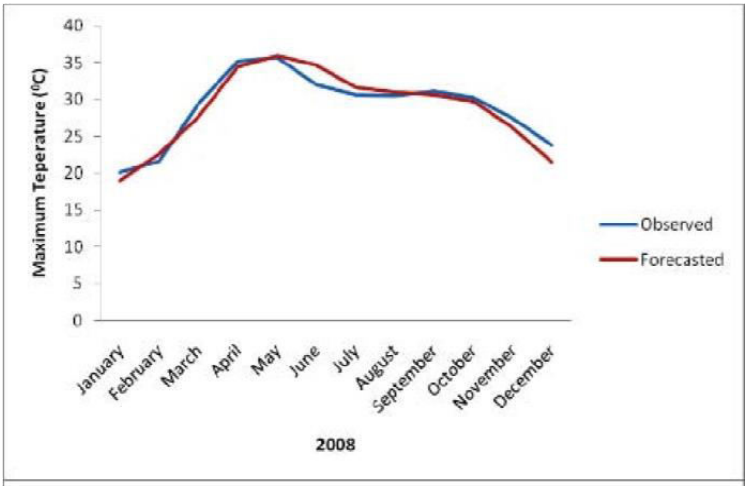

Figure 3: Comparison of observed and forecasted monthly maximum temperature

To plot the real and forecasted values of the daily average that has been detected, in terms of temperature, it can be assessed by the following lines of code,

```
In [26]: ax = one_step_df.T_mu_actual['2015':].plot(label='observed', figsize=(20, 15))
         pred_dynamic.predicted_mean.plot(label='Dynamic Forecast', ax=ax)

         ax.fill_between(pred_dynamic_ci.index,
                         pred_dynamic_ci.iloc[:, 0],
                         pred_dynamic_ci.iloc[:, 1], color='k', alpha=.25)


         ax.set_xlabel('Date')
         ax.set_ylabel('Temperature (in Celsius)')
         plt.ylim([-20,30])
         plt.legend()
         plt.show()
```

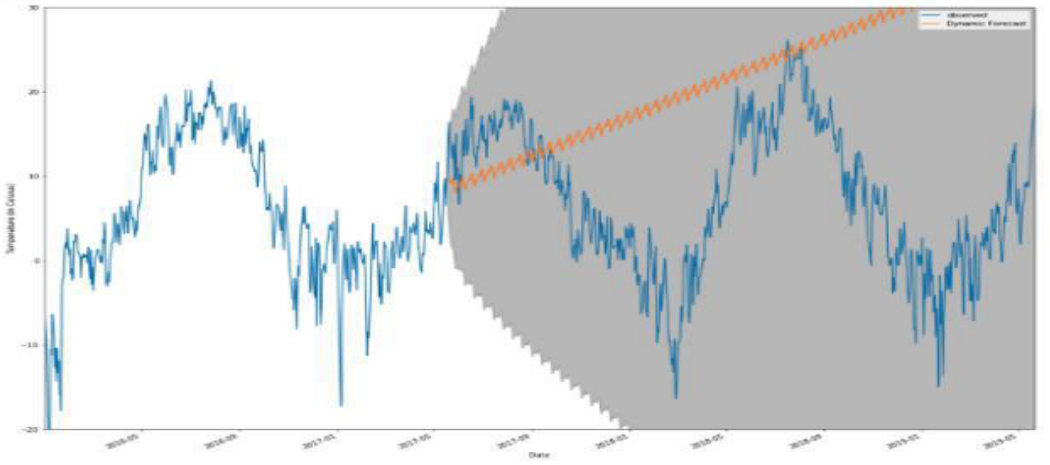

Figure 4:Fore Casted values

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V. CONCLUSION AND FUTURE WORK

In India there is a need to develop forecasting models on continuing basis and also for different agro-climatic zones due to visible effects of changing environment conditions and weather shifts at different locations and areas. Therefore, knowledge of trend is likely to be helpful in planning and production of enterprises/crops. The study was undertaken to apply some specific weather forecasting models based on time series data. On the basis of RMSE, (the study recommended that SARIMA model is the most efficient model for forecasting of monthly maximum temperature, monthly minimum temperature and Monthly Humidity I. In this paper, weather data is considered with different attributes for weather forecasting. The weather forecasting experiment was carried out to analyze the performance of different machine learning techniques.We trained three different models on this data SVM, ANN and time series RNN. We then used these models to predict weather and calculated root mean square error from the actual temperature. From observation of this project, we found out that time series using RNN is a better method for weather forecasting.

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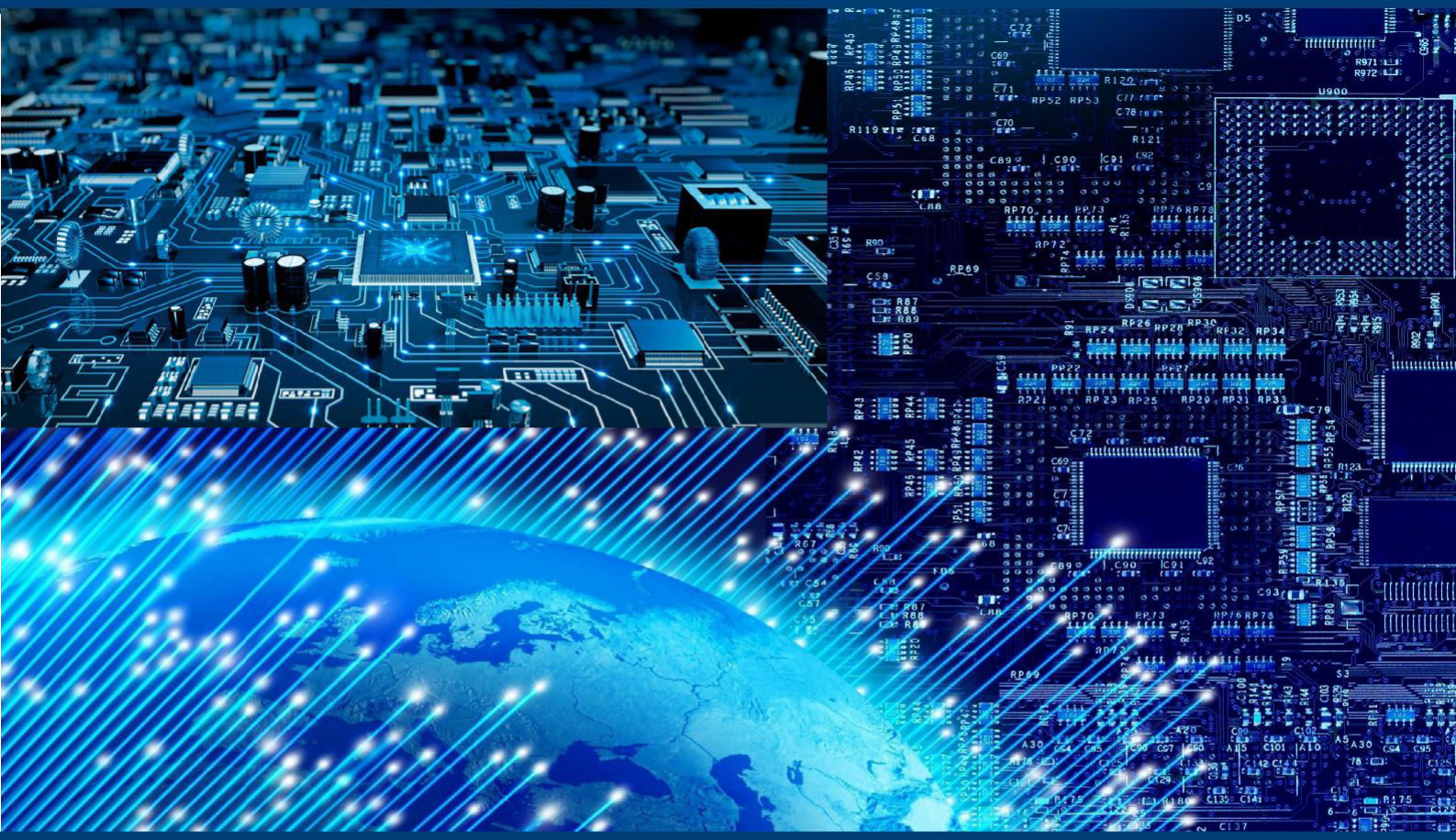

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