Weather Trend Forecasting

Hemanth Yarra

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Abstract

Weather forecasting is a crucial application in meteorology that helps in predicting future weather conditions based on historical data and various meteorological parameters. This project focuses on analyzing weather trends and implementing forecasting models using time series techniques such as SARIMA and Facebook's Prophet model. The dataset utilized consists of global weather conditions with detailed attributes such as temperature, humidity, wind speed, and air quality indices.

1 Introduction

Weather prediction plays a significant role in various sectors, including agriculture, transportation, and disaster management. Accurate forecasting can help mitigate the risks associated with extreme weather events and improve planning in critical industries. This project aims to analyze historical weather data, identify trends, and build predictive models to forecast future weather conditions efficiently.

2 Dataset Description

The dataset used in this study was obtained from Kaggle and consists of multiple meteorological parameters such as:

- Temperature in Celsius
- Wind speed and direction
- Atmospheric pressure
- Humidity and precipitation levels
- Air quality indices including Carbon Monoxide, Ozone, and Nitrogen Dioxide
- Moon phase and visibility

The dataset was preprocessed to handle missing values and ensure consistency in time-series data.

3 Exploratory Data Analysis (EDA)

Exploratory Data Analysis was performed to gain insights into the dataset. Various visualizations such as box plots, histograms, and heatmaps were generated to understand the distribution of meteorological variables and detect any anomalies or outliers.

3.1 Outlier Analysis

A box plot analysis was conducted to check for extreme values in temperature readings across different countries. Outliers were examined and handled appropriately to avoid skewing model predictions.

3.2 Correlation Analysis

A heatmap was generated to identify correlations among different meteorological parameters. Temperature showed significant correlations with humidity, pressure, and air quality indices, which were considered while building predictive models.

4 Time Series Forecasting

Time-series forecasting models were implemented to predict future temperature trends. Two main models were considered:

- **SARIMA Model:** A Seasonal AutoRegressive Integrated Moving Average model was used to analyze temperature trends, considering seasonality and lag-based dependencies.
- **Prophet Model:** Developed by Facebook, the Prophet model is effective for time-series forecasting, incorporating trend and seasonal variations.

4.1 SARIMA Model Implementation

The SARIMA model was trained on historical temperature data using the following steps:

- Data transformation to ensure stationarity (using differencing techniques).
- Parameter tuning using ACF and PACF plots to determine optimal values for p, d, and q.
- Model evaluation using metrics such as Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE).

4.2 Prophet Model Implementation

The Prophet model was trained by formatting the dataset into a time-series structure with date as the primary index. The model was then used to generate 30-day future predictions, with visualizations illustrating forecasted temperature trends and confidence intervals.

5 Results and Discussion

The forecasting models provided accurate predictions for temperature trends. The SARIMA model captured short-term fluctuations effectively, while the Prophet model provided robust long-term trend predictions.

5.1 Model Evaluation

The performance of both models was evaluated using:

- **Mean Absolute Error (MAE):** Measures the average absolute error between actual and predicted values.
- **Root Mean Squared Error (RMSE):** Captures the magnitude of prediction errors.

The evaluation results indicated that the Prophet model performed slightly better in long-term forecasting, while SARIMA excelled in capturing seasonal patterns.

6 Conclusion and Future Work

In this study, weather trend forecasting was conducted using time-series models to predict future temperature variations. The models successfully captured historical trends and provided reliable forecasts. Future work can focus on integrating additional meteorological variables and exploring deep learning approaches such as LSTMs to enhance predictive accuracy.

7 References

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- Taylor, S.J., Letham, B. (2018). Forecasting at Scale with Prophet.
- Kaggle Dataset: Global Weather Repository.