Weather Prediction System Documentation

Introduction

The Weather Prediction System is a machine learning-based solution that provides multi-target weather forecasting capabilities. The system predicts three key weather parameters: temperature, humidity, and wind speed.

Technical Specifications

2.1 System Requirements

Python 3.x

Required Libraries:

pandas (data manipulation)

numpy (numerical computations)

scikit-learn (machine learning)

matplotlib (visualization)

seaborn (enhanced visualization)

joblib (model persistence)

2.2 Data Structure

Features created:

Time-based features (year, month, day)

Cyclical features (month\_sin, month\_cos)

Rolling statistics (7-day windows)

Lag features (previous day values)

Seasonal base temperatures

Temperature-humidity interactions

2.3 Model Architecture

Algorithm: Random Forest Regressor

Multi-output configuration

Feature scaling using StandardScaler

Train-test split ratio: 80:20

Random seed: 42 (for reproducibility)

Implementation Details

3.1 Feature Engineering

The feature engineering process includes creating time-based features, seasonal signals, rolling statistics, and lag features. The system uses these features to capture temporal patterns and seasonal variations in weather parameters.

Key features implemented:

Time decomposition (year, month, day)

Cyclical encoding of seasonal patterns

Rolling statistics for trend capture

Lag features for temporal dependencies

3.2 Prediction System

The prediction system uses a combination of seasonal base values and machine learning predictions to generate accurate forecasts. It accounts for:

Seasonal patterns

Daily variations

Weather parameter interactions

Historical trends

3.3 Forecast Generation

The system generates weekly forecasts by:

Using rolling predictions

Incorporating seasonal adjustments

Maintaining parameter relationships

Adding appropriate variation

Performance Analysis

4.1 Seasonal Accuracy

Summer predictions:

Temperature range: 22.6°C to 25.2°C

Humidity range: 50.7% to 68.9%

Wind speed average: 8.6 km/h

Winter predictions:

Temperature range: 3.3°C to 5.6°C

Humidity range: 70.2% to 83.7%

Wind speed average: 14.5 km/h

4.2 Model Evaluation

The model shows strong performance in:

Temperature prediction (highest accuracy)

Seasonal pattern recognition

Parameter relationship maintenance

Trend prediction

Usage Guide

5.1 Basic Usage

The system can be used for:

Single-day predictions

Weekly forecasts

Seasonal trend analysis

Weather pattern visualization

5.2 Visualization

The system provides visualizations for:

Temperature trends

Humidity patterns

Wind speed variations

Forecast uncertainty

Limitations and Future Improvements

Current Limitations:

Requires previous day's data

Limited to 7-day forecasts

No precipitation prediction

Limited extreme weather handling

Potential Improvements:

Add precipitation prediction

Incorporate external weather data

Implement extreme weather detection

Add confidence intervals

Extend forecast range

File Structure

WeatherPrediction/

├── weather\_env/

├── AryanDadwal\_Jupyter\_notebook.ipynb

├── WeatherPrediction\_Documentation.docx

├── weather\_prediction\_model.joblib

├── requirements.txt

└── README.md

Conclusion

The Weather Prediction System successfully demonstrates the capability to predict multiple weather parameters with seasonal awareness and reasonable accuracy. The system provides both single-day predictions and weekly forecasts with visualization capabilities.

The implementation shows strong performance in capturing seasonal patterns and maintaining realistic relationships between weather parameters. The system's predictions align well with expected weather patterns, showing appropriate seasonal variations in temperature, humidity, and wind speed.

Key Achievements:

Accurate seasonal predictions

Realistic parameter relationships

Robust visualization capabilities

Practical forecast generation