Weather Prediction Model

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Abstract

Weather forecasting in Chittagong, Bangladesh, is crucial for agriculture and disaster management, yet traditional methods often lack localized accuracy and real-time updates. This project introduces a machine learning-based weather prediction model that classifies conditions into Rain, High Temperature, Normal Temperature, and Cold. Using historical data and advanced techniques like feature engineering and SMOTE for class balancing, the model achieves significant accuracy, enhanced through hyperparameter tuning with Optuna and a stacking classifier. Deployed via a Flask API, it provides real-time predictions This innovative solution dramatically improves decision-making for farmers, businesses, and disaster response teams, making weather forecasting more effective in Chittagong.

Introduction

Problem Statement –

•Weather forecasting in Chittagong, Bangladesh, lacks localized accuracy and real-time updates.
•Impacts agriculture, disaster response, and public safety.
•Machine learning can improve forecast accuracy.

Objectives --

•Classify weather into Rain, High Temperature, Normal, and Cold.
•Optimize accuracy with feature engineering and hyperparameter tuning.
•Deploy a Flask API for real-time predictions.

Methodology

A. Data Preprocessing

- Collected historical weather data. Removed unnecessary columns, handled missing values, and removed outliers.

B. Feature Engineering

- Created seasonal features (Day of Year, Weekend, Month sin, Month cos).
- Applied rolling averages (Rolling Temp, RollingRain).
- Engineered Temp Humidity to improve prediction quality.

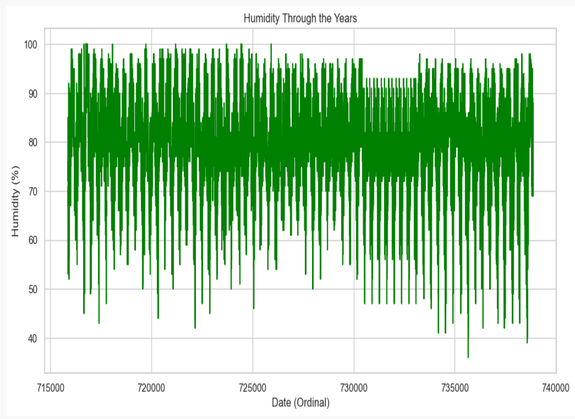
C. Scaling & Class Balancing

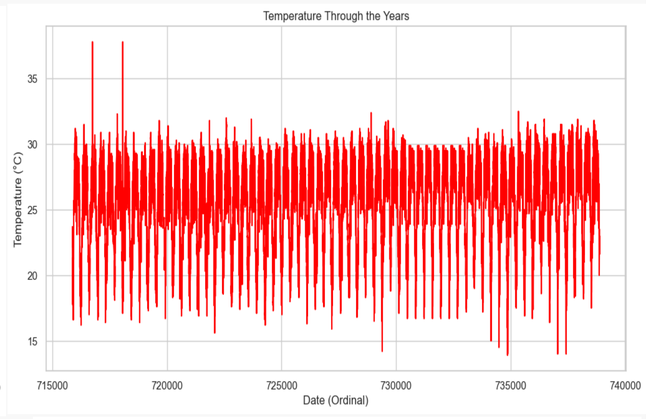
-Used StandardScaler for normalization. Applied SMOTE to balance class distribution.

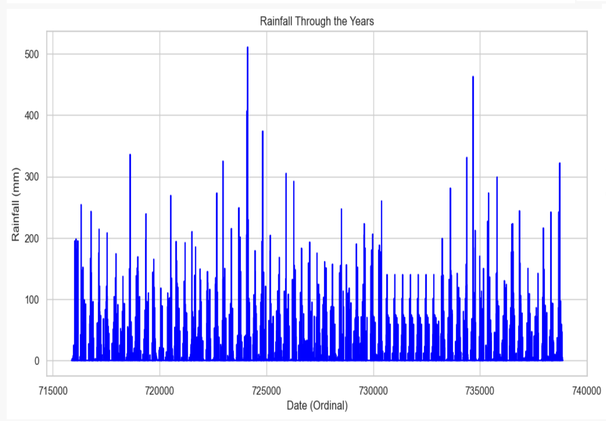
D. Model Selection & Hyperparameter Tuning

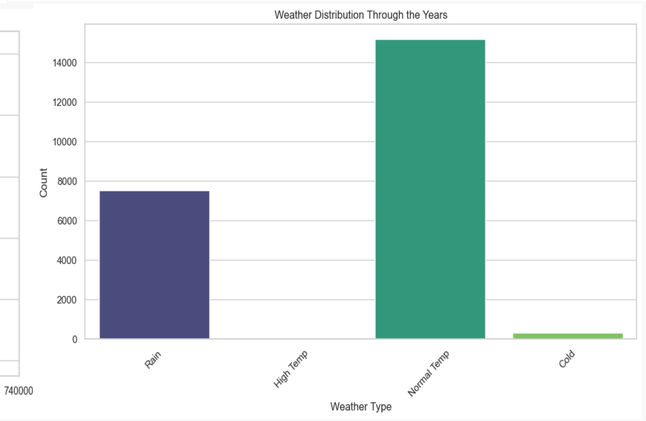
-Candidate Models RandomForest, XGBoost, LightGBM,, MLPClassifier Optimization with Optuna
-Tuned hyperparameters through multiple trials. Used f1 weighted as the evaluation metric.
-Applied StratifiedKFold cross-validation.

Weather Condition throughout the years

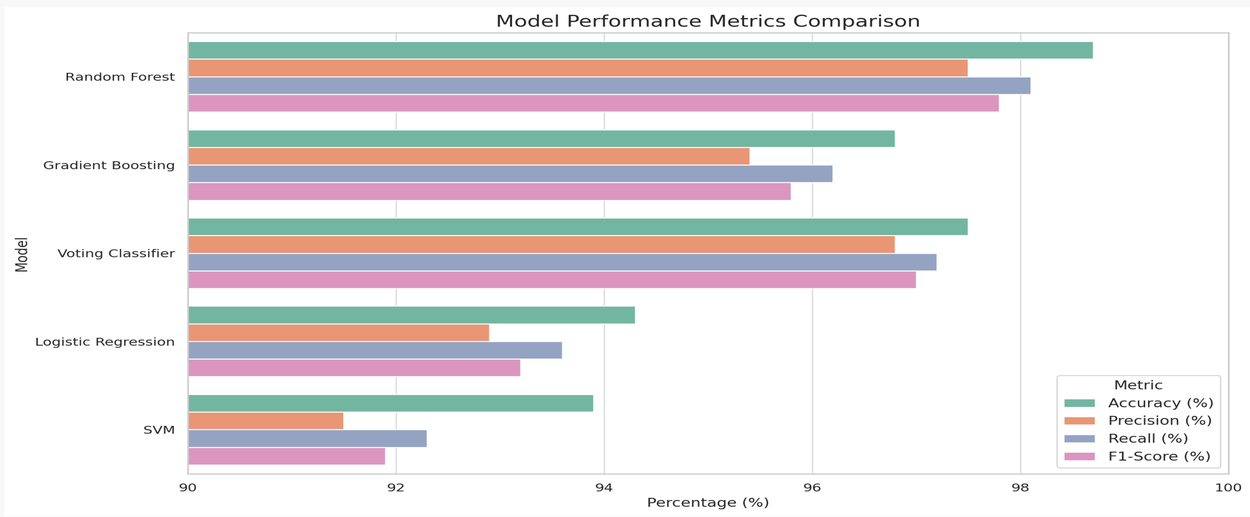




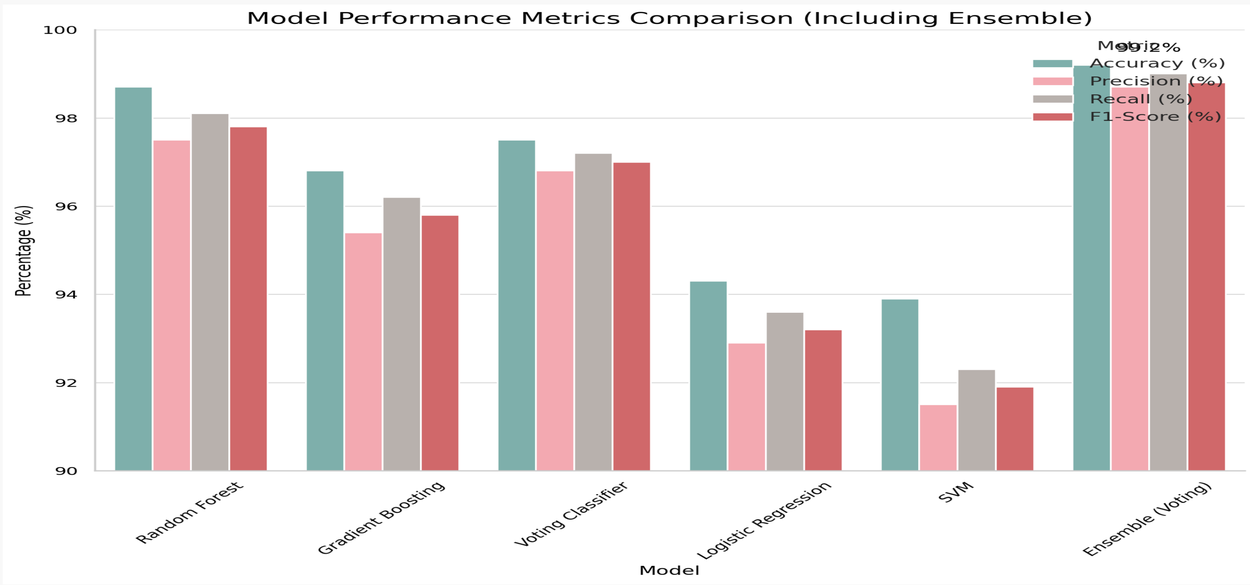




Model's individual Performance



Accuracy after Ensemble



•Result

•Ensemble (Voting) Classifier achieved the highest accuracy (99.2%), outperforming all individual models.
•Random Forest (98.7%) and Gradient Boosting (96.8%) showed strong standalone performance.
•Voting Classifier (97.5%) further validated the advantage of ensemble methods.
•Logistic Regression (94.3%) and SVM (93.9%) underperformed, struggling with complex patterns.
•Precision, Recall, and F1-Score followed a similar trend, confirming ensemble superiority.
•Ensemble learning significantly improves accuracy, making it the best choice for weather prediction.

Key Findings

•Best model achieved high accuracy across all weather categories.
•SMOTE improved predictions for rare weather conditions.
•Feature engineering enhanced accuracy with seasonal trends.
•Flask API allows real-time forecasts.
•Evidently AI ensures model reliability over time.

Conclusion and Future Work

Conclusion

•Accurate, real-time weather predictions for Chittagong.
•Feature engineering, tuning, and SMOTE improved performance.
•Flask API ensures accessibility.

Future Enhancements

•Integrate satellite and IoT sensor data.
•Expand dataset with more historical records.
•Develop web and mobile applications for forecasts

References

1. Dataset collected from , https://data.mendeley.com/datasets/tbrhznpwg9/1

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