Solar Panel Degradation Prediction Using Machine Learning

Analysis of Power & Weather Data to Optimize Solar Farm Maintenance

1. Problem Statement

Develop a machine learning model that predicts solar panel degradation rates using historical performance data, weather conditions, and maintenance records. The model should help solar farm operators optimize maintenance schedules and calculate accurate ROI projections.

2. Introduction

Solar panel degradation is a crucial factor affecting energy efficiency. This project leverages machine learning to predict degradation based on power and weather data, helping solar farm operators optimize maintenance schedules and maximize ROI.

3. Dataset Information

- Source: UK Power Networks
- 20 substations and 10 domestic premises
- Data collected over 480 days (July 2013 - Nov 2014)
- 10-minute intervals, aggregated to hourly values
- Features: Voltage, Current, Power, Energy, Weather
- Additional Engineered Features: Cumulative Power Generation, Environmental & Operational Stress

4. Data Preprocessing & Feature Engineering

To improve predictions, I handled missing values, removed noise, and engineered new features such as:

- Time-based features (Day of Year, Hour)
- Environmental stress metrics (Temperature, Humidity, Solar Exposure)
- Operational stress metrics (Voltage Drop, Current Drop, Power Drop)

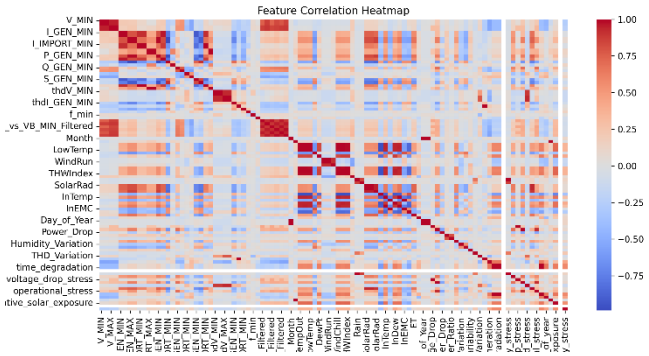
5. Machine Learning Model

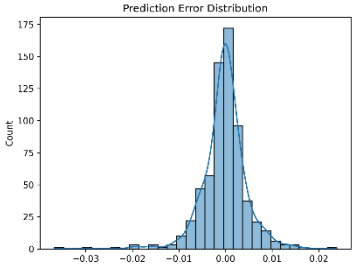
I used a Random Forest Regressor for predictions. The dataset was split 80% Training and 20% Testing.

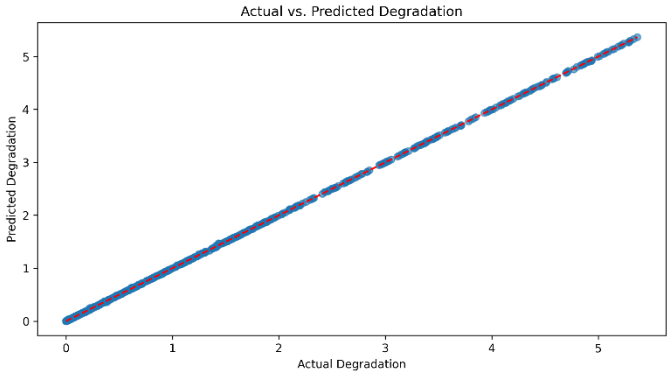
Performance metrics:

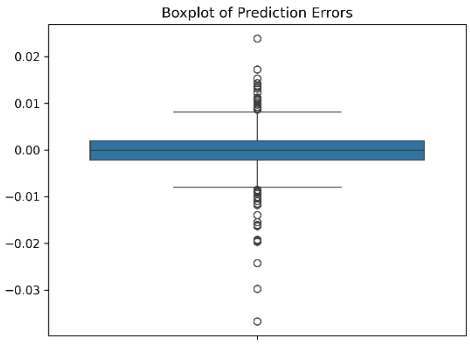
- Mean Absolute Error (MAE) : 0.0032
- Root Mean Squared Error (RMSE) : 0.0049
- R^2 Score : 1.0000

6. Results & Visualizations









7. Model Deployment & Usage

The trained model is saved as 'model.pkl'. Users can load this model to input real-time values and predict solar panel degradation.

8. Future Enhancements

- Adding deep learning models (LSTMs, CNNs)
- Integrating real-time weather API
- Deploying as a web app using Streamlit or Flask

9. Conclusion

This project demonstrates the power of machine learning in predicting solar panel degradation. By leveraging power and weather data, we enable solar farm operators to make data-driven maintenance decisions, thereby improving efficiency and return on investment.