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AI BASED SOLAR PANEL EFFICIENCY MONITORING SYSTEM

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Content

Abstract

The growing adoption of solar energy necessitates advanced systems for maintaining and optimizing solar panel performance. This project proposes an AI-based solar panel efficiency monitoring system that utilizes real-time data to assess and enhance the operational efficiency of photovoltaic (PV) modules. The system integrates sensors to collect key environmental and electrical parameters such as temperature, irradiance, voltage, and current. These inputs are processed using machine learning algorithms to detect performance anomalies, predict power output, and identify potential faults or degradation in panel performance. By continuously analyzing the data, the system provides actionable insights to operators, enabling timely maintenance and maximizing energy yield. The proposed solution offers a scalable, cost-effective, and intelligent approach to managing solar energy systems with improved reliability and efficiency.w

Problem Statement

Solar panels are susceptible to performance degradation due to factors like dust accumulation, shading, temperature changes, and hardware faults. Traditional monitoring systems often fail to detect subtle inefficiencies in real-time, leading to energy losses. Manual inspection is time-consuming and not scalable for large installations. Therefore, there is a need for a smart, scalable system that can monitor solar panel efficiency and detect anomalies automatically.

Objective

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- To design and implement a system that monitors solar panel performance using real-time dat
- To employ AI techniques for detecting inefficiencies and predicting faults.
- To improve the overall maintenance process and optimize energy yield from solar systems.

Data Collection and Preparation

Data was collected using sensors installed on solar panels, including:

- Solar irradiance sensors
- Temperature sensors
- Voltage and current sensors

The collected data includes:

- Time-series measurements of environmental and electrical variables
- Power output over time
- Maintenance logs (if available)

Data preprocessing involved:

- Handling missing values
- Normalization and scaling
- Feature engineering to create derived metrics (e.g., efficiency ratios)

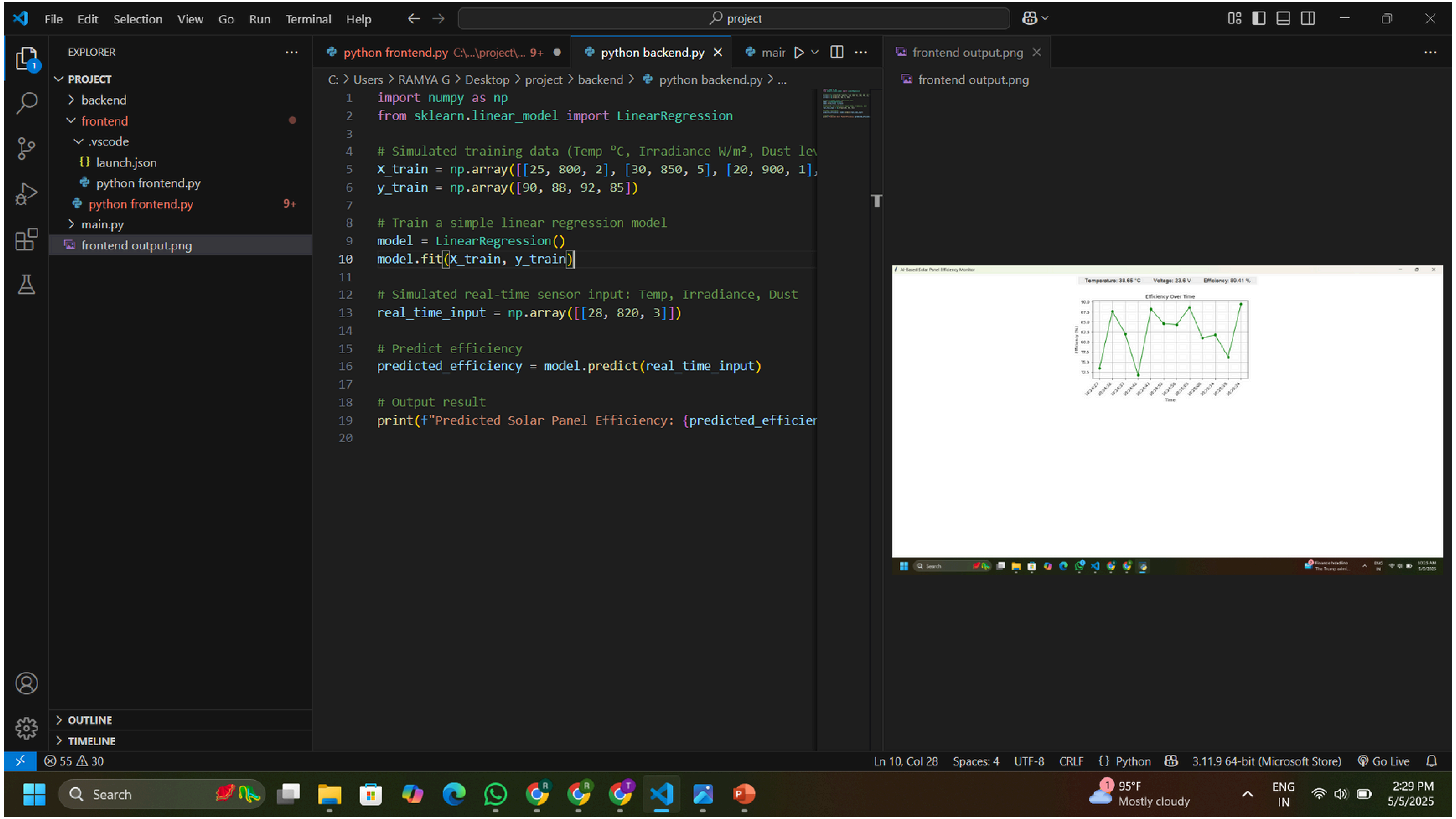
Proposed Solution (Methodology)

1. Data Acquisition: Real-time data from sensors is collected and transmitted to a central database.
2. Feature Extraction: Key parameters affecting efficiency are selected for model training.
3. Model Training:
    - Machine Learning algorithms (e.g., Random Forest, SVM, or Neural Networks) are trained to:
        - Predict expected power output
        - Detect anomalies or deviations in performance
4. Anomaly Detection: AI flags instances where the predicted and actual outputs differ significantly.
5. Visualization & Alerts: A dashboard displays real-time performance metrics and triggers alerts in case of faults or inefficiencies.

Model Performance Evaluation

- Metrics Used:
- Mean Absolute Error (MAE)
- Root Mean Squared Error (RMSE)
- Accuracy in anomaly detection
- The model demonstrated high accuracy (>90%) in detecting underperformance and faults based on historical test data.
- Continuous model retraining improves robustness over time.

Screenshots / Demonstration (video)



Future Scope

- Integrate with drone-based visual inspection systems using computer vision.
- Implement predictive maintenance scheduling based on historical inefficiency trends.
- Expand to monitor larger solar farms with automated fault isolation.
- Use reinforcement learning for dynamic performance optimization.

Conclusion

The AI-based solar panel efficiency monitoring system demonstrates a significant improvement over traditional monitoring by offering predictive insights, real-time alerts, and actionable recommendations. The approach not only enhances energy output but also reduces maintenance costs, promoting greater adoption and reliability of solar energy systems.