edunet foundation

Solar Energy Prediction-ML

Learning Objectives

The goal of this project is to build a web application that can predict solar energy output based on various weather and time features, using machine learning. The application must provide both a modern, interactive website (frontend) for users and a backend (server) that handles prediction requests by running a trained ML model.

Source : www.freepik.com/

Tools and Technology used

ML Training: Python, scikit-learn, pandas, numpy, pickle

Backend: Node.js, Express.js, csv-parser, cors

Frontend: HTML5, CSS3, JavaScript, Chart.js

Version Control: Git and GitHub (GitHub repo: solar energy prediction) to manage code and

Methodology

Data Generation and Feature Engineering

A synthetic dataset of 300 hourly records was created, simulating solar energy data for January 2023.

Feature engineering was performed to improve predictive power:Extracted time-based features: `hour`, `weekday`, `day`, `month`, and cyclical encoding to capture daily cycles.

Environmental / weatherfeatures : `temperature`, `humidity`, `cloud_cover` ,`solar_irradiance` `wind_speed`, etc. Rolling averages for `solar_irradiance`, `temperature`, `cloud_cover`.

ML Model Training The project used a **Random Forest Regressor** (an advanced, ensemble-based machine learning model) for prediction, built using the engineered dataset.

Data was split (80% for training, 20% for testing). The model reached around **94% accuracy** (R^2 score) on test data.

The model was saved (`model.pkl`) and integrated into the backend.

Web Application Development

- **Backend**: Built with Node.js and Express.js.
- **Frontend**: Built with HTML, CSS, and JavaScript.

Problem Statement:

Developing an accurate, interactive web-based system for solar energy prediction remains a significant challenge for both researchers and energy practitioners. The prediction of solar energy output is complicated by the variability of weather conditions and daily/seasonal patterns, making it difficult for end-users, researchers, or utilities to plan energy usage, grid integration, or system performance. There is a need for a user-friendly yet advanced solution that can:

- Ingest time and weather data,
- Automatically engineer relevant features,
- Apply powerful machine learning algorithms for accurate forecasting,
- And present predictions and insights through a modern, accessible web interface.

Solution:

This project provides a complete **web application** for accurate solar energy prediction and visualization, featuring:

Data Simulation and Feature Engineering

Generates a synthetic solar energy dataset with 300 hourly records, including environmental, temporal, and solar-related features.
Performs advanced feature engineering such as extracting hour, weekday, rolling averages, cyclical (sin/cos) encoding, and daylight indicators to capture patterns relevant to solar energy forecasting.

Machine Learning Model

Trains a **Random Forest Regressor** on the engineered dataset to predict solar energy output based on all relevant factors.
Achieves high prediction accuracy (~94%), providing reliable estimates of future solar energy output.

Backend Development (Node.js + Express)

Implements an Express.js API server that:
Serves user requests for data and predictions.
Loads and utilizes the trained machine learning model for real-time inference.
Handles feature processing transparently to users.

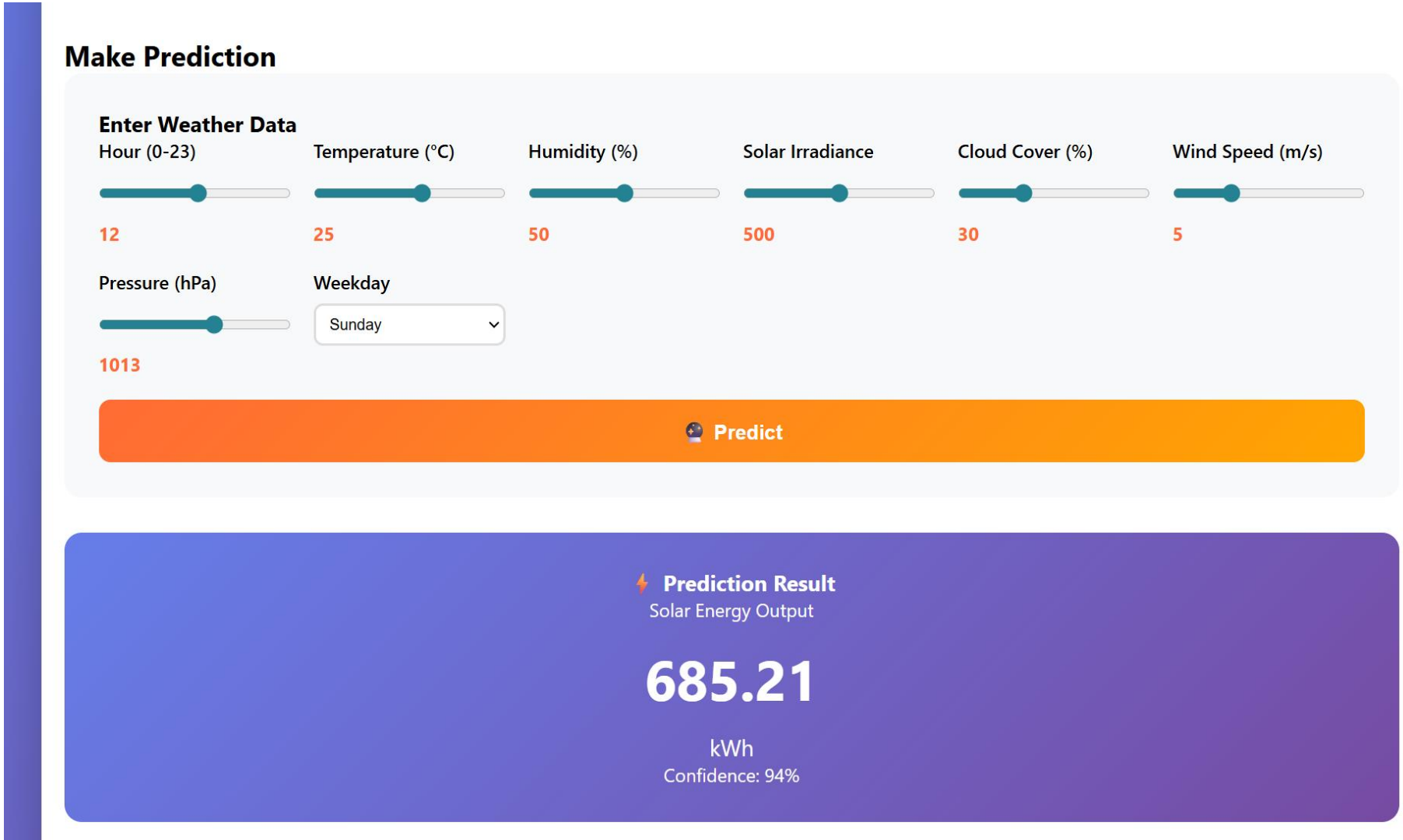
Frontend Dashboard (HTML, CSS, JavaScript, Chart.js)

Offers a modern, interactive dashboard that:
Visualizes the dataset and model outputs using Chart.js for trends, distributions, and relationships.
Allows users to input custom weather and time features to generate real-time solar energy predictions.
Presents project, model, and data information clearly.

User Experience and Accessibility

Delivered as a single ZIP file with complete documentation, easy setup, and all dependencies included.
Ready to run locally in VS Code with minimal setup, suitable for demos, education, and further development.

Screenshot of Output:



Conclusion:

This project successfully demonstrates how machine learning and modern web technologies can be combined to solve real-world forecasting challenges in the renewable energy sector. By simulating and engineering a robust solar energy dataset, training a high-accuracy Random Forest regression model, and deploying it with an interactive full-stack web application

- Reliable solar energy predictions based on key weather and time features,
- Powerful data visualization and exploration tools,
- Real-time, user-driven predictions in a browser-friendly dashboard,
- A portable, easy-to-run package that can be used for education, experimentation, or as a foundation for deeper research.