2024

CAE SUMMER INTERNSHIP

ENVIRONMENTAL SCALE

旅遊島嶼用電需求時空分析

Temporal Analysis of Electricity Demand on Green Island

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Introduction

Green Island (綠島, Ludao) currently relies on diesel power generation, which is unstable and has high carbon emissions. To utilize the island's abundant solar and wind energy resources, it is essential to understand the energy demand. This study predicts and analyses the island's electricity demand at a high temporal resolution using historical weather data, population trends, and tourist activity. The results are valuable to plan for sustainable energy infrastructure capacity.

Methodology

Datasets: Weather, population, and tourist data from various sources were collected for the years 2017-2024.

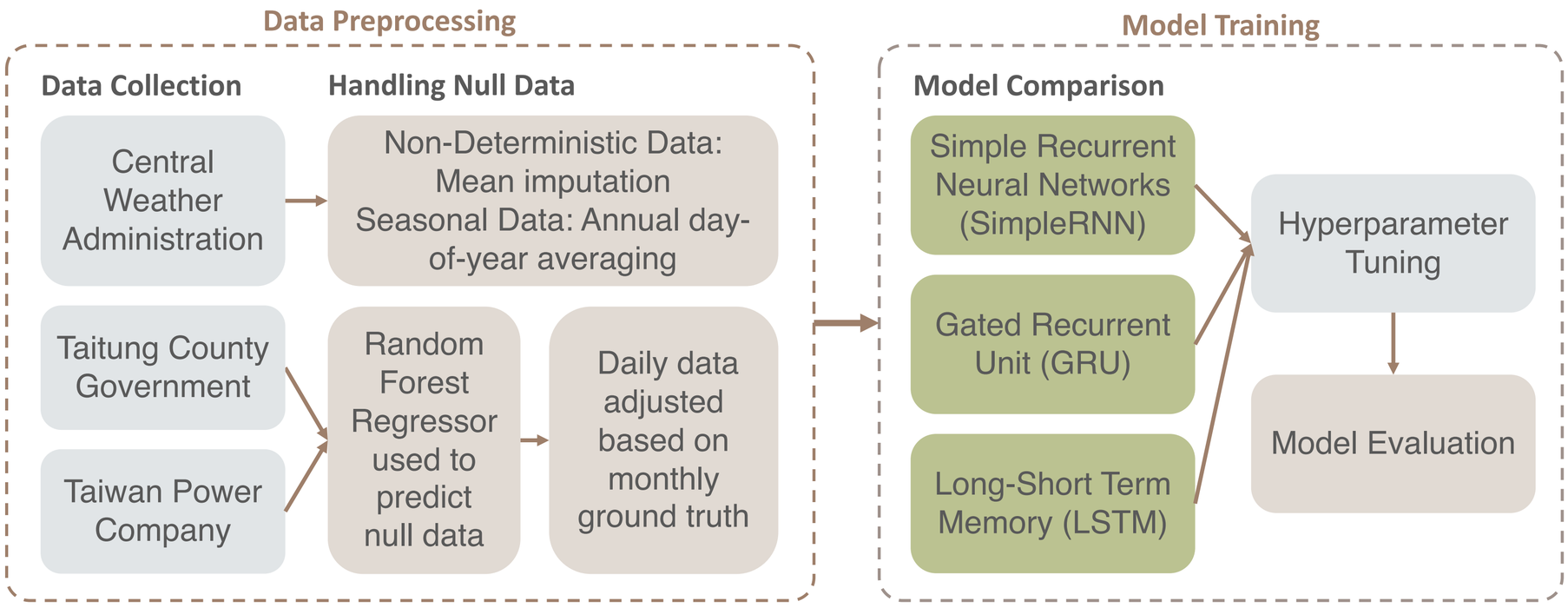


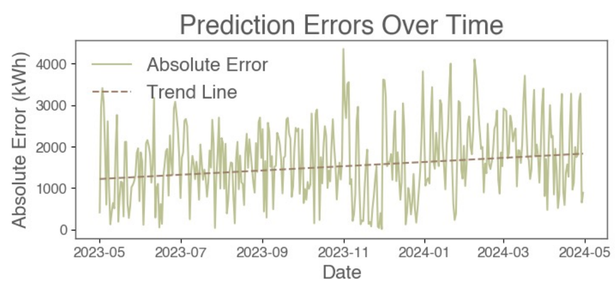
Figure 1: Research design

Results

Figure 2: Comparative results of different models on test set

Model \ Metric	MAE	RMSE	R^2
SimpleRNN	2212	2603	0.77
GRU	1430	1681	0.91
LSTM	2197	2546	0.80

Figure 3: Prediction error of the GRU-based model over time



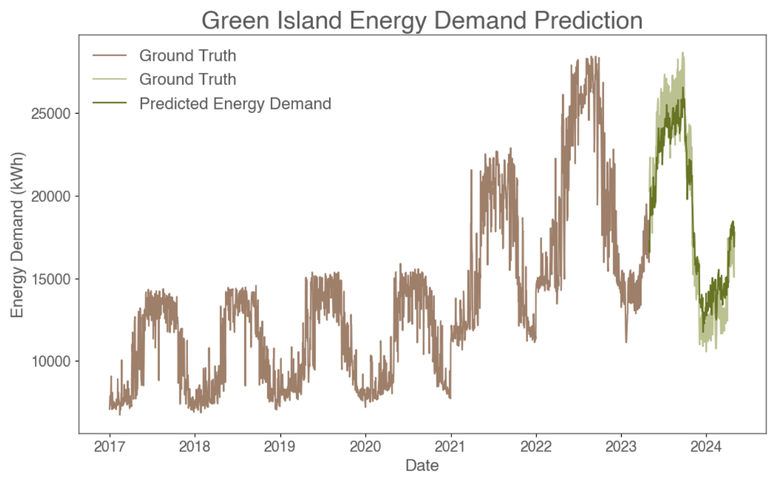


Figure 4: Predicted energy demand of the GRU-based model with ground truth

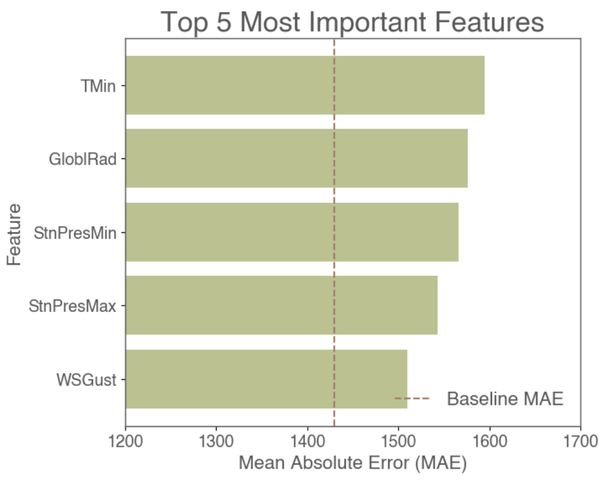


Figure 5: Top 5 most important features

Model

The model was trained with a 365 lookback period using a GRU-based architecture. Early-stopping was implemented with a patience of 10 epochs to prevent overfitting.

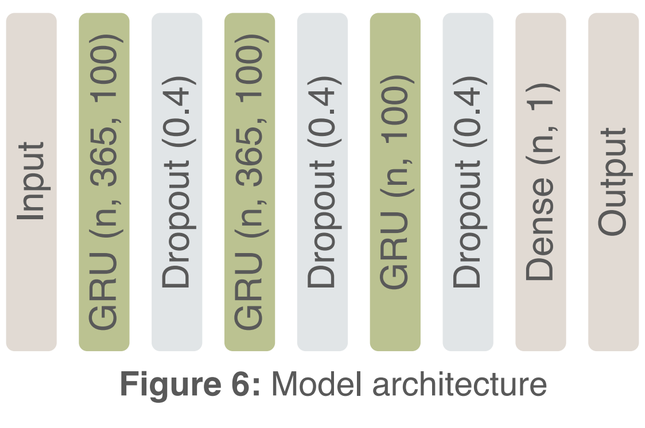


Figure 6: Model architecture

Discussion

- It is observed that electricity demand is relative to seasonal changes and is more sensitive to weather features such as temperature and radiation.
- Among the three models used, GRU strikes a balance between complexity and the ability to learn long-term dependencies. This balance allows GRU to perform effectively with the limited data available in this study, outperforming both LSTMs, which require more data and computational resources, and SimpleRNNs, which struggle with capturing long-term dependencies.
- In real-world scenarios, smart meters and automatic weather stations can be used to transmit real-time data to update the model.

Future Work

- Assign weights to the electricity demand of different buildings to reflect trends across various areas of Green Island.
- Collect cellular data and quality data from longer historic periods.