Grenoble INP
École Nationale Supérieure de l'Énergie, l'Eau et l'Environnement
21 Av. des Martyrs, 38031 Grenoble, France

M2 SGB: Machine Learning & Optimization

Influence of Weather on Energy Consumption

Academic year 2022-2023

Sara IZADI
Tiwalade OYEBODE
AL-Mu'tez billah AL-SQOUR

Contents

1 Abstract

This paper analyses the correlation in a smart home between weather and energy consumption (electrical and gas consumption), using a machine-learning model known as Regression. The aim is to observe if weather conditions modify consumption habits in the household.

2 Introduction

Demand prediction and demand response are becoming more and more crucial because of the rising proportion of renewable energies in the electrical mix and the accompanying unpredictability of electricity generation. The need for electricity frequently varies with the weather; for example, when it is cloudier, there is a greater demand for inside illumination. Solar panels are also currently producing less electricity than usual. Order to ensure grid stability and timely activation of backup resources, this requires the forecasting of the electrical demand. The necessary generation can then be coordinated by grid operators to meet the demand. In this work, we evaluate a decision tree regression performance in estimating the electricity consumption and gas usage of a smart home using weather information. Wind, rain, and UV index are the factors employed. The property is equipped with gas heating. This study's objectives are to identify the meteorological factors best suited for use in making predictions of this nature and to identify plausible reasons for the findings. However, obtaining the most precise results is not the objective. Many more variables, such as historical energy use (from a week ago, today, etc.), must be taken into account to produce a performance that is more accurate.

Weather plays a significant role in energy consumption as it affects the demand for heating and cooling, which are major energy loads. Understanding the relationship between weather and energy consumption can help improve energy demand forecasting and aid in the development of strategies for managing energy consumption. Additionally, by analyzing the impact of weather on energy consumption, utilities and governments can make better decisions on energy generation and distribution. For example wind, rain, and UV can have an impact on energy consumption in smart homes in various ways.

- **Wind**: Strong winds can cause damage to solar panels, and may decrease the efficiency of wind turbines, which can lead to a decrease in the amount of energy generated by these sources.
- **Rain**: Rain can affect the production of solar energy, as it can decrease the amount of sunlight reaching the panels. However, it can also increase hydropower production.
- **UV**: UV radiation is essential for solar power generation. A high level of UV radiation can increase the efficiency of solar panels and thus increase the amount of energy generated.

In smart homes, the weather conditions can be monitored, and the energy usage can be adjusted accordingly. For example, when it is sunny, the smart home may increase the use of solar power and decrease the use of grid electricity. Similarly, when it is windy, the smart home may increase the use of wind power and decrease the use of grid electricity. Overall, the effect of wind, rain, and UV on energy consumption in smart homes will depend on the specific weather conditions and the specific energy systems in place, but they can be used to optimize the energy consumption in the smart home.

3 Methodology

Regression in machine learning is the process of training a model to predict a continuous target variable based on one or more input features. The goal of regression is to find the mathematical relationship between the input features and the target variable, so that the model can make accurate predictions for new, unseen data.

In our model we used Decision tree regression which models the relationship between the target variable and the input features using a decision tree structure. It is good at handling data with multiple levels of interactions among the features. Evaluating the performance of a decision tree regression model for estimating the electricity consumption and gas usage of a smart home using weather information, such as wind, rain, and UV index, would involve several steps.

- **Data collection**: Collecting historical data on electricity consumption and gas usage of the smart home, as well as weather data such as wind speed, precipitation, and UV index for the same time period.
- **Data preprocessing**: Cleaning and preparing the data for analysis, including handling missing or outliers values.
- **Model training**: Using the collected data to train the decision tree regression model to predict electricity consumption and gas usage based on the weather factors.
- **Model evaluation**: Using a set of evaluation metrics such as mean absolute error (MAE) and accuracy to evaluate the model's performance.
- **Model tuning**: Optimizing the model by adjusting the parameters, such as the depth of the decision tree, to improve the model performance.
- **Final evaluation**: Using the final model to make predictions on a separate set of test data and comparing the results with the actual consumption and gas usage to evaluate the model's overall performance.

4 Results

The results of the predictions by the decision tree regressor and random forest regression model. We used the three features Wind, Rain and UV, and using the regressor we tried to determine the most important feature as seen in figure 1, wind is the most important feature to determine electrical consumption.

However, for gas consumption, we can see from figure 2 that the most important feature was the UV index when predicting gas consumption.

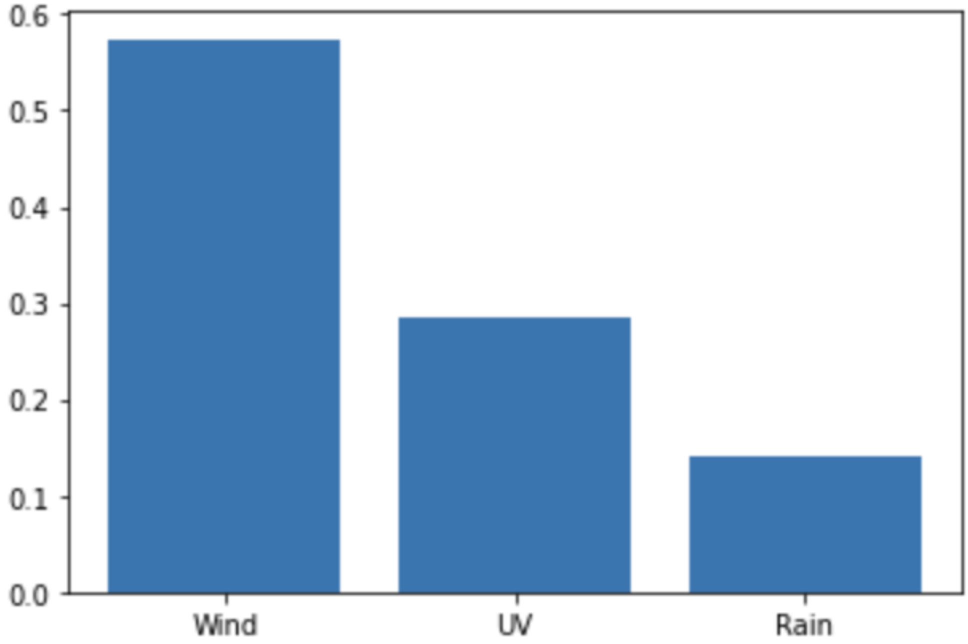

Figure 1: Feature Importance for Electrical Consumption

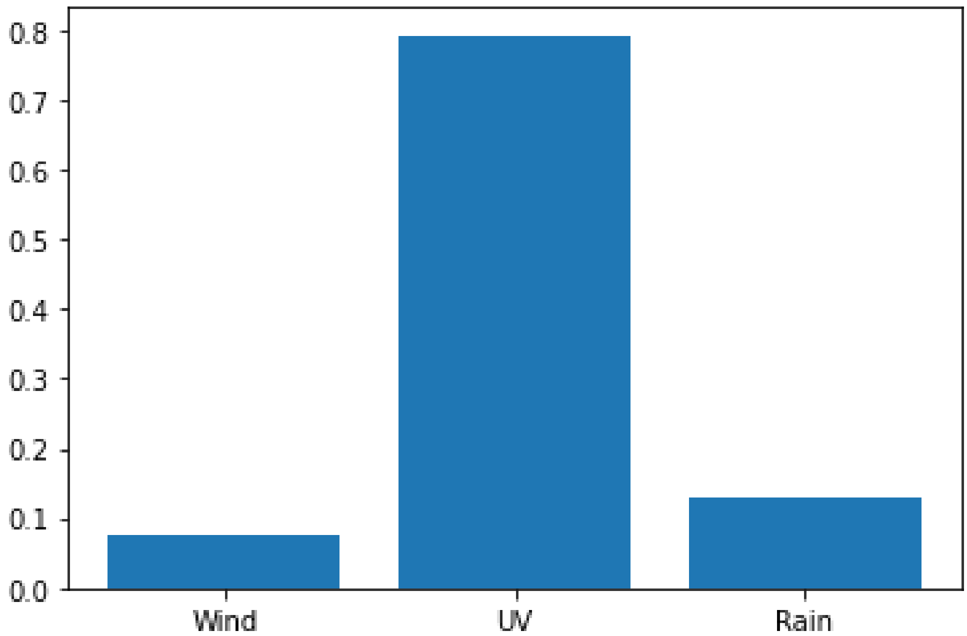

Figure 2: Feature Importance for Gas Consumption

4.1 Electrical Consumption Prediction with Decision Tree and Random Forest Regression Model

From figure 3 and figure 4 show the accuracy and mean absolute error of using the decision tree and random forest model respectively. We can see that we have better accuracy with the random forest model.

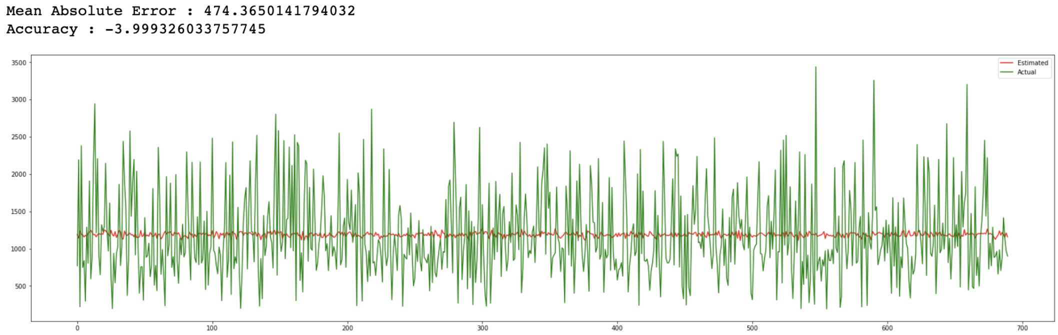

Figure 3: Decision Tree Prediction of Electrical Consumption

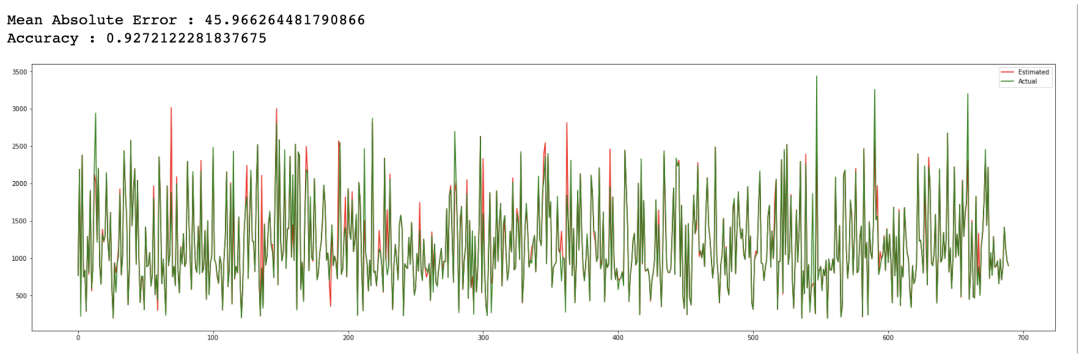

Figure 4: Random Forest Prediction of Electrical Consumption

4.2 Gas Consumption Prediction with Decision Tree and Random Forest Regression Model

From figure 5 and figure 6 show the accuracy and mean absolute error of using the decision tree and random forest model respectively. However we can see unlike the electrical consumption prediction, we have the same values for the mean absolute error and accuracy for both regression modael.

```
Mean Absolute Error : 0.0011109519424524063
Accuracy : 0.9993034857132946
```

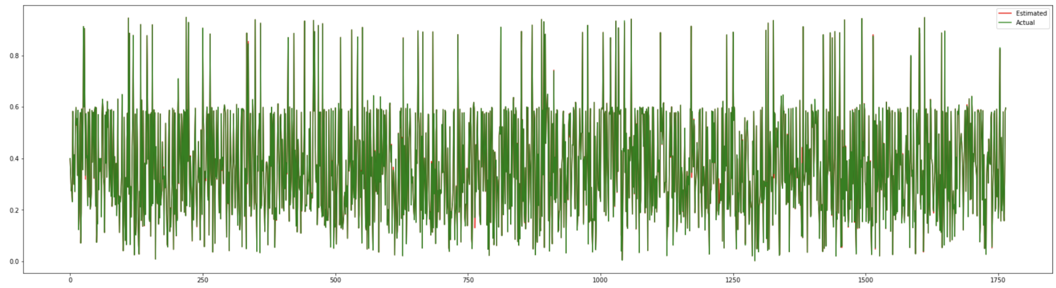

Figure 5: Decision Tree Prediction of Gas

```
Mean Absolute Error : 0.0011109519424524063
Accuracy : 0.9993034857132946
```

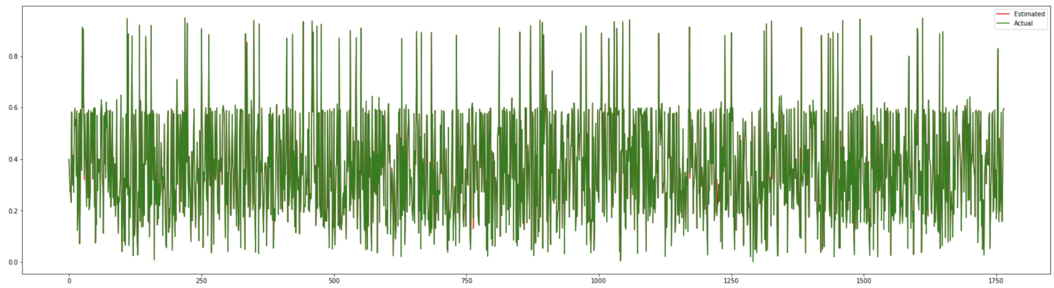

Figure 6: Random Forest Prediction of Gas

5 Conclusion

From our results, we can conclude that for gas consumption in a smart using weather data, decision tree and random forest regression models are able to provide accurate consumption prediction. However, for the electrical consumption prediction random forest model is best for carrying out the prediction analysis.