Predicting Energy Consumption using Time Series Analysis: A Comparison of ARIMA, UCM, and Deep Learning Models

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1. Introduction

In this study, the performance of various models, including ARIMA, UCM and deep learning models, is evaluated using energy consumption data collected every 10 minutes throughout the year 2017. To do this, different combinations of hyperparameters and architectures for each model class are tested and the performance of the models is compared using MAE metrics. The results show that deep learning models, specifically the transformer model, perform slightly better than the other models.

2. Methods

The models were compared using the same MAE metric and the predictions of the deep learning model were made recursively like the other two. The month of November was used as a validation dataset for comparing the performance of the models. Once the best model was chosen for each class, the models were retrained using the entire dataset.

ARIMA Models

A seasonal difference of 144 days is inserted in every ARIMA model. Starting by adding the order of AR and MA (both normal and seasonal) gradually, until a residual PACF and ACF that seem the least correlated is obtained, the process is continued until the predictions are in fact worse than the previous model. A regressor that tracks the hours of the day is also used. The model with the best MAE and the best PACF and ACF plots is (2,0,2)(2,1,2)[144] (fig.1 and fig.2). CSS method in R is used for the training in order to shorten the training time.

Deep Learning Model

For the deep learning model, a transformer model is used, and its parameters are tweaked. The transformer has 5 blocks and 8 heads and is mapped into a dense layer with some dropouts throughout the layers to prevent overfitting. The regressor used tracks the hours of the day. The input data has a shape of

- (batch size, 144, 2)

and the target has a shape of

- (batch size, 6, 1).

The training is done with a GeForce GTX 1070 for 8 hours.

UCM Models

For the UCM models, a local linear trend, seasonal dummy is added to model the daily seasonality and a regressor for the hours of the day. Variations of the final, optimal model, that are simplified versions of it, are tested.

MAE metrics is used to compare the performance of these models and it is found that the transformer deep learning model performs the best among all the models.

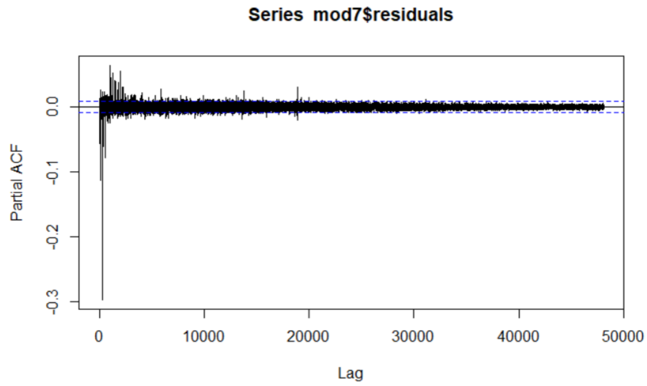

Figure 1. We see some significant spikes over the first lags, but they are so many that it is possible that they are under the 5%.

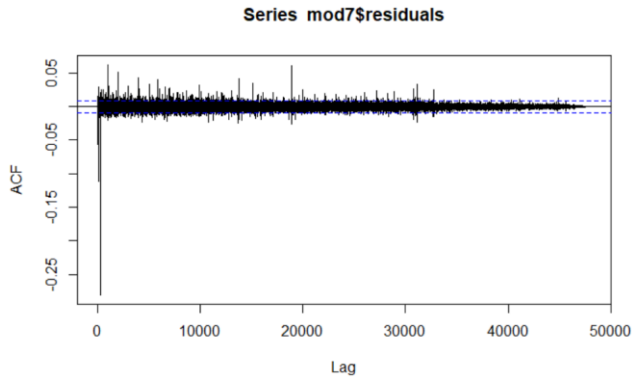

Figure 2. The ACF plot seems as uncorrelated as the PACF and we can do the same consideration for the 5% of significant spikes on the first lags.

3. Results

The models were compared using the Mean Absolute Error (MAE) metric. The results are summarized in the table below:

Model	MAE
Transformer	988.1459
ARIMA (2,0,2)(2,1,2)[144]	1001.241
UCM	1002.356

As we can see from the table, the transformer deep learning model had the lowest MAE of 988.1459, followed by the ARIMA model with 1001.241, and the UCM with 1002.356. This suggests that the transformer model was the most accurate in predicting energy consumption.

It is worth noting that the transformer model had a slightly lower MAE than the other two models, indicating that this could be due to its ability to learn complex patterns in the data and its capacity to handle large amounts of data.

In summary, the transformer deep learning model proved to be the best performing model among the three models tested in this study, with a MAE of 988.1459.

4. Conclusions

In this study, the performance of three models for energy consumption prediction was evaluated. The models evaluated were ARIMA, UCM and a transformer deep learning model. The month of November 2017 was used as a validation dataset for comparing the performance of the models and, once the best model was chosen for each class, the models were retrained using the entire dataset.

The results of this study showed that the transformer deep learning model had the lowest Mean Absolute Error (MAE) of 988.1459, followed by the ARIMA with 1001.241and the UCM model with 1002.356. Consequently, it was concluded that the transformer deep learning model was the best performing model among the three models tested in this study for energy consumption prediction.