Forecasting next month's air temperature for estimating heating demand

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Temperature prediction is a widely applicable and important subject for various economical branches such as civil engineering, agricultural, and energy trading for heating resources. Not only due to political circumstances is the latter one a timely topic when it comes to natural gas as a heating fuel. Long-term energy forecasting for assessing the demand of natural gas poses a complicated task. Hence, the prediction of temperature anomalies could support this process.

Introduction and objectives

The objective was to estimate mean surface air temperature anomalies in Switzerland for lead-times of two fortnightly periods (t1 and t2). Such forecasts are highly uncertain because of the chaotic nature of weather processes. The input features for the forecasts were set to be local variables for the target region (Switzerland) as well as multiple weather indexes such as the southern oscillation index and arctic oscillation. Developing methods to incorporate the polar vortex intensity into the prediction posed as an additional objective.

Research design

The project involved gaining an understanding of the task, its applications, and the data, by applying the CRISP-DM approach: business and data understanding; data preparation; modelling; and evaluation. Literature was summarized on the topics of machine learning based temperature forecasting and weather phenomena. Developing multiple polar vortex indices was part of the feature engineering during the preparation stage.

Results

Two indices were developed for assessing the polar vortex condition. One based on temperature and the other based on wind speed. Both of these were included as an input feature for the classification and regression models. Furthermore, image clustering with the K-Means model yielded insights on how frequent certain states have occurred in the past. Both, classification models and a regression model were proposed for the temperature anomaly prediction. Analysing the results of the developed models, it showed that both types have moderate predictive skill. A random forest classifier, a multi-layer perceptron classifier and regressor, and a recurrent neural network classifier were tested. The classification models were set up to predict if the given lead-times will be above or below the historical mean temperature. For both two weekly periods, the accuracy of the best classification model was approximately 0.66 on the test set. The RMSE of the regression model was around 2.5 Kelvin on both timespans, which was on par with the evaluated literature.

Implications and recommendations

Although, the developed polar vortex indices did convey some information about the polar vortex intensity, their parameters could be optimized further. Additionally, the possibilities of the clustering approach should be explored further to be more conclusive. The machine learning models on the other hand beat the set benchmark and could thus be utilized for the forecasting process in energy consumption.

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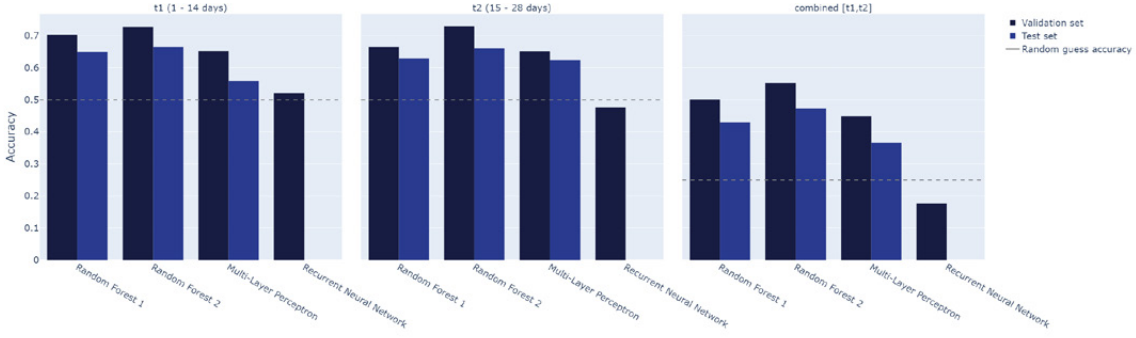

Figure 1: Model accuracies