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Foundation model for time-series forecasting : Amazing adaptation to data

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1. Introduction

Existing research on machine learning has focused on developing time series prediction models that specialize in data from a single domain. While these models acquire knowledge specific to that domain, they have limitations that make it difficult to apply them to time series data from other domains. Especially in the case of various signal processing experiments in the nuclear field, the security and accessibility of the data limits the variety of experiments. Therefore, this research aims to develop a foundation model-based time series model that acquires generalized knowledge by utilizing time series data from various domains. [1,2] Experimental results show that foundation models make effective predictions even when trained with time series data from other domains. In this paper, we aim to develop an effective time series-based foundation model using unlabeled samples from multiple domains. In our experiments, we utilized public data provided by Darts [3] and changed the domain of the training model to test the adaptability of the underlying model to different domains. The experimental results showed that the foundation model trained with various domains improves the performance of existing machine learning techniques. We also confirmed that the prediction performance of pre-trained foundation models with related domains is better than learning various domains at once.

2. Methods and Results

In this section, we will verify the performance of the FacebookProphet model, a foundation model technique that has been shown to be effective in predicting existing time series, and the performance for different types of domains.

2.1 Foundation model

In this study, we used the Facebook Prophet model to check the adaptive performance of the model for different domains.
Prophet is an open source library for time series data forecasting developed by Facebook. The Prophet model uses powerful time series analysis to automatically detect and predict trends, seasonality, and holiday effects in data. The models are designed to be easy to use and automatically adjust parameters to make modeling and forecasting simple for users.
In this study, we used ReLU as an activation function to train the Prophet model and ran experiments with batch sizes of 32 and 50.
In this experiment, we tried to forecast time series data 5 years ahead, setting the output chunk length to 12, performing an autoregressive method inside the model and using past output values as input sequentially.

2.2 Covariate

In addition to the time series being forecasted, Prophet models can take as input a series of covariates, which are auxiliary variables. Auxiliary variables are time series data that are not directly forecasted but provide additional stationary that is useful to the model. The model uses two types of covariates: past covariates and future covariates.
The past covariates are unknowns prior to the time of prediction: values that need to be measured or things that are not known in advance. On the other hand, future covariates are known up to the time period you want to predict. By utilizing these two auxiliary variables, the Prophet model can improve its forecasting performance.

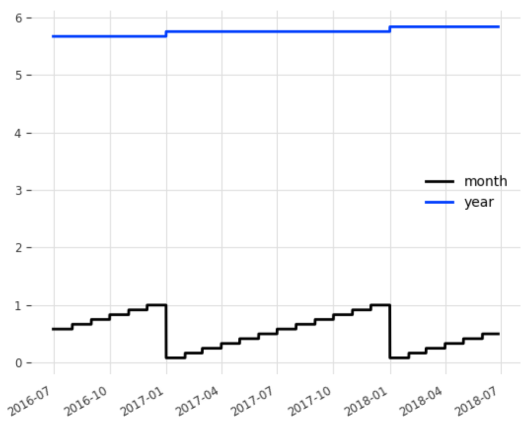

Fig. 1. Yearly and Monthly covariates for Etth1dataset.

2.3 Forecasting

To validate the performance of the foundation model, we performed comparisons using the following scenarios First, we pre-trained the ETTh1 dataset by adding yearly and monthly covariates to help it learn, and second, we pre-trained it with Airpassenger data, which is completely unrelated to the ETTh1 data. In Figure 2, in (a), the foundation model shows good prediction performance because it is trained with relevant data. In (b), we trained the foundation model with completely unrelated data, airline passenger data, and made predictions. We found that the prediction is not as detailed as in (a), but it is still quite good.

In Figure 3, we quantitatively evaluate the performance of the foundation model using MAPE. We can see that the MAPE value when training with ETTh1 data and covariates is not significantly different from the MAPE value when training with airline passenger data alone. We plan to conduct further experiments to confirm that more training is needed for better prediction performance.

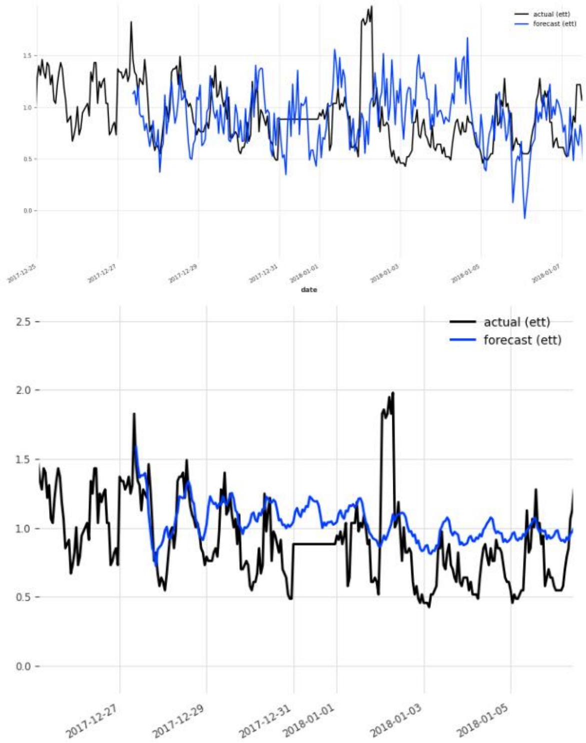

Fig. 2 Forecasting plot using foundation model.

(a) : Performance of foundation model pre-trained with covariates and Etth1 data.
(b) : Performance of foundation model pre-trained using only AirPassenger.

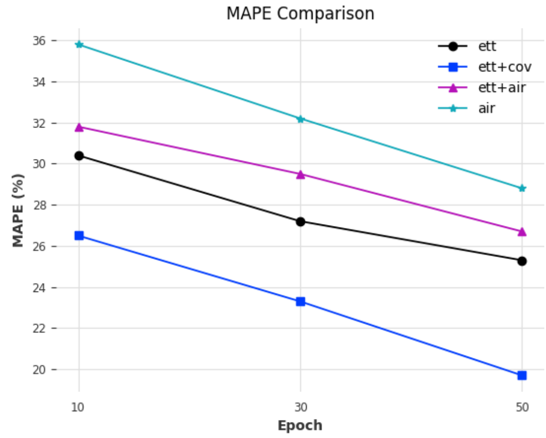

Fig. 3. MAPE comparison

2.4 Data set

The datasets used in this paper are time series datasets published by Darts, including Airpassengers, Electiricity, and ETTh1. As shown in Figure 4, we can see that the frequency of Airpassenger data is completely unrelated to the frequency of Etth1 data.

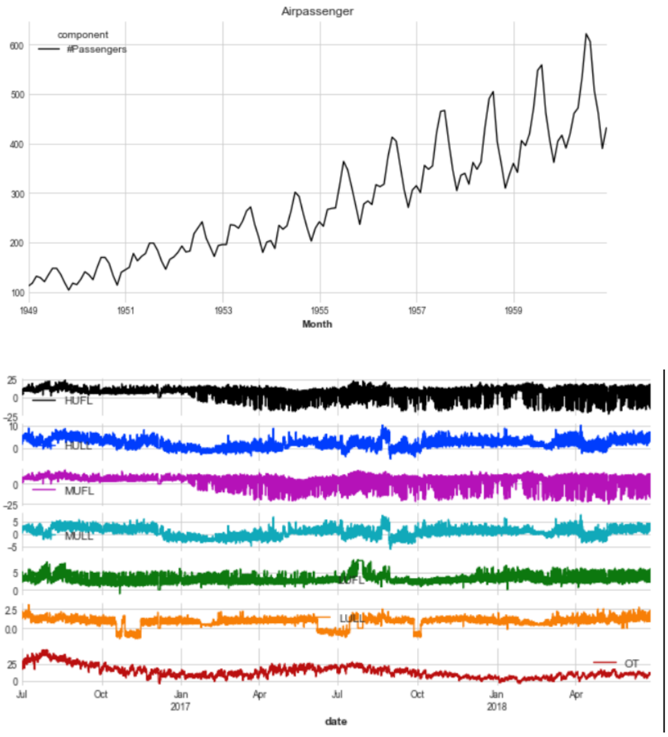

Fig. 4. AirPassenger dataset and Etth1 dataset

3. Conclusions

Prediction tools utilizing foundation models are useful tools for their universal applicability. Among its various usefulness, the adaptability of the foundation model to data has been verified in this experiment. Therefore, it is expected to solve many of the difficulties in research due to the inaccessibility and scarcity of the nuclear power domain.

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