УДК 51.74

NON-STATIONARY TIME SERIES MODELING WITH THE NEURAL ORDINARY DIFFERENTIAL EQUATIONS

Голованев Яков (Университет ИТМО)
Научный руководитель –к.ф.-м.н., Хватов А.А. (Университет ИТМО**)**

Long-short term memory (LSTM) networks are widely used for data-driven time series modeling. Nevertheless, LSTM networks cannot model both the trend and local behavior of the time series, which is especially critical for time series with complicated trend component forms. Additionally, recently proposed neural ordinary differential equations (neural ODEs) allow explicitly modeling time series completely with ODE solutions, theoretically increasing the overall model performance.

Usually, a neural network consists of a discrete set of transformations on the input vector, resulting in dense representation that solves various problems. Neural networks learning is highly developed area, that has a vast amount of different frameworks. However, for many practical problems, the treatment of the output data resulting from a sequence of discrete transformations on input data is very rough and unnatural. One prominent example is the time series data, which is usually continuous by its nature. A significant breakthrough in continuous-time neural networks was achieved in the recent papers developing Neural Ordinary Differential Equations, where authors modeled the network output using ODE and efficiently backpropagate through it. We suppose that it is possible to achieve a performance boost on different types of non-stationary time series, since by investigating the underlying ODE system, we can conclude that, for example, it will be possible to efficiently model the time series trend with an ODE solution.

We conduct several experiments on various nature processes time-series datasets, comparing the existing implementation of neural ODE model with several classical time series models, including LSTM networks. This experiment indicates that the observed neural ODE model was not able to model the samples from the temperature dataset with strongly periodic data, which contradicts the theoretical considerations. To investigate this problem, we conducted various experiments on the synthetic data, showing the theoretical capabilities of directly learning the required class of functions. Experiments reveal that the data should be passed to the model in a very specific way to learn the ODE corresponding to a specific function. To further investigate this phenomenon, we consistently conduct the experiments on nature processes data, varying the trend and the extrapolation window size, allowing us to model the non-stationary trend, which was not achieved with LSTM networks.

The use of considered model class can significantly improve the quality of time series forecasting, which is crucial for various engineering, financial, or healthcare tasks, additionally allowing to achieve a better understanding of the underlying processes, since the ODE systems are well-studied and can be interpreted and analyzed, unlike the series of transformations in RNNs, such as LSTMs.

Голованев Я.С. (автор) Подпись

Хватов А.А. (научный руководитель) Подпись