A new photovoltaic power forecasting method using hybrid neural-prophet-LSTM model

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Introduction

Under the background of global warming and the depletion of fossil energy, the development and utilization of renewable energy has become the primary development goal of all countries in the world. As one of the green energy, photovoltaic power(PV) generation technology has become one of the main power generation methods in the world in recent years because of its low cost, low geographical requirements and many application scenarios. However, PV as an intermittent energy has great randomness and uncertainty. In order to solve this problem, we propose a method that can accurately predict photovoltaic power generation.

This study newly introduces a reliable PV power forecasting method based on neural-prophet(NP) and skip-time long short-term memory (ST-LSTM) models.

Methodology

We use neural-prophet (NP)[1] and LSTM to build the network model, NP as the main prediction model and SK LSTM as the auxiliary prediction model. Firstly, the prediction value is obtained by NP model prediction, and then compared with the real value to construct the error data set. The error value is used as the input of ST-LSTM model to obtain the prediction error value. Then the error value obtained by ST-LSTM model is combined with NP model to obtain the final prediction value.

- Prophet, also known as Fb-prophet, is a decomposable time series forecasting model developed by Facebook's Core Data Science Team. NP consists of different components such as trend, seasonality, auto-regression, additional regressors, and so on. Prophet has three main model components, which are trend, seasonality, and holidays. These components are combined with Eq1.

$$y(t) = g(t) + s(t) + h(t) + e(t) \qquad (1)$$

Here, g(t) is a trend-model function that can be specified as a linear function or a logistic function;

- s(t) represents a seasonality function that can be daily, weekly, and/or yearly, which is handled with Fourier terms; h(t) is a holiday function that considers the effect of holidays, which occur irregularly; e(t) represents the error changes that are not fitted by the model.
- The flow chart of NP model is shown in Fig.1

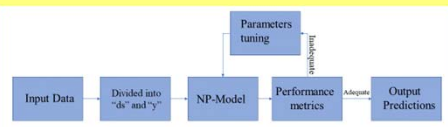

Fig.1. The flow chart of NP model.

LSTM is one kind of recurrent neural network (RNN) model, which can solve the short-term dependency problem by learning the long-term dependencies of the parameters. The basic structure for the LSTM model consists of four layers, which are represented in Fig.2.And the final model flowchart is shown in Fig.3.

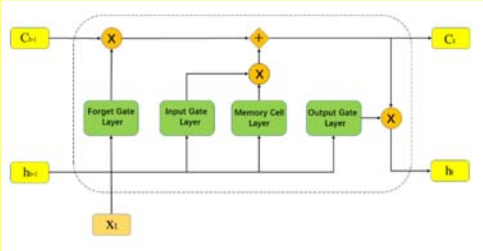

Fig.2. The basic structure of LSTM model.

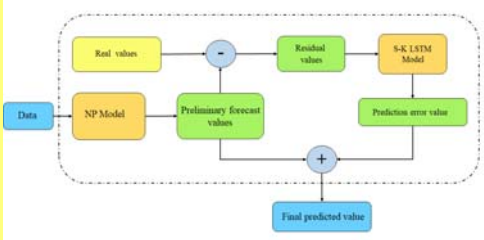

Fig.3. The final flow chart of Hybrid models.

Experiment

DATASET

In this paper, the 1A Trina (10.5kW, mono-Si, Dual, 2009), the DKASC, Alice Springs PV system data was used in the following case research. The five years (2015-2019) data was selected for this case, and the data resolution is 5-min. The data from 2015 to 2017 were set as the training dataset. The data in 2018 was set as the validation dataset. The data in 2019 was set as the test dataset.

EVALUATION METRICS

$$RMSE = \sqrt{\frac{1}{N}\sum_{t=1}^{N}\left(\hat{I}(t) - I(t)\right)^2} \qquad (2)$$

Results

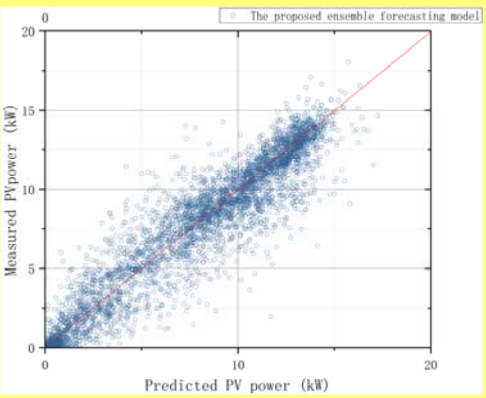

Fig. 4. Relationship between predicted value and actual.

The prediction results are shown in Fig.4 and Fig.5. As one can see in Fig.5, The blue triangle represents the predicted value of the LSTM model at each time, the red circle represents the predicted value of the hybrid model at each time, and the black square represents the actual value. We can see that the curve predicted by the hybrid model has a good fitting effect.

In order to fully illustrate that NP-ST-LSTM has good prediction effect, we built other models and carried out experiments. The experimental results are shown in Tab.1.

Table 1. Error metrics compared proposed models with other models for hourly ahead forecasting.

Method	RMSE	MAE
LSTM	1.095	0.576
GRU	1.124	0.634
NP-ST-LSTM	1.060	0.537

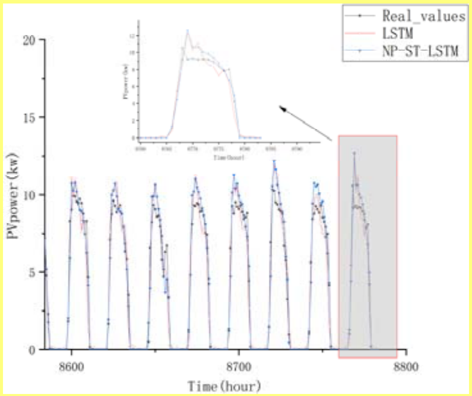

Fig. 3. Predicted value and real values.

Conclusions

Accurate prediction of photovoltaic power generation is of great significance for providing end users with high-quality power and improving the reliability of power system operation. Although this is a widely studied problem, it is still far from being solved. At present, the most advanced method based on deep learning mainly optimizes the loss of mean square error, resulting in fuzzy prediction. In order to solve the periodic and intermittent problems of photovoltaic power generation, a np-cnn-lstm hybrid model is proposed in this paper. In this paper, we use real data sets to evaluate the proposed model, and then evaluate the performance of single model and mixed model on the same data set. The experimental results show that this method is effective in photovoltaic power generation prediction.The work of this paper confirms the potential of np-cnn-lstm hybrid model in predicting time series data with periodic characteristics, and provides a useful reference for the practical management application of smart grid. In the future work, we hope to improve the prediction range and accuracy by using all sky images.

References

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