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Research on Short-term Power Prediction of Distributed Photovoltaic Power Generation

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Abstract: With the vigorous development of solar photovoltaic power generation, accurate prediction of short-term photovoltaic power generation has become an important issue. However, since the short-term power generation of photovoltaic power generation is affected by many environmental factors and has great uncertainty, the safe operation of the power grid is challenged. Therefore, it is necessary to simulate the power generation in advance through data models and predict the power generation amount. The power grid relies on the valuation and makes corresponding adjustments to maintain the stability of the power grid system.

Keywords: Photovoltaic Power Generation; Machine Learning; Short-term Power Prediction Method.

1. Introduction

With the obvious trend of global climate warming, fossil energy consumption is serious, and various extreme climates occur frequently, causing serious economic losses. Clean energy has received great attention from all walks of life. With the transformation of the country's energy structure, power grids containing a high proportion of renewable energy will become the mainstream trend. The connection of a large number of photovoltaic power generation to the grid accelerates the optimal allocation of energy and provides guarantee for the comprehensive dispatch of the power system. Due to the strong volatility of photovoltaic power generation, this will be detrimental to the grid connection and subsequent safe operation of photovoltaic power generation.

Photovoltaic power generation is affected by many factors such as time, temperature, weather, etc. As a result, traditional models cannot accurately predict solar photovoltaic power generation when dealing with complex situations, which will pose challenges to the stable operation of the power grid and even cause extremely huge economic losses. No matter how the load of the power generation system changes, the output of photovoltaic power generation cannot change with the change of load. When photovoltaic power generation is connected to the large power grid, other energy sources must be added for complementary coordination. Only by accurately predicting photovoltaic power generation can we solve the above problems and promote the sustainable development of photovoltaic power generation.

2. Influencing Factors

Short-term photovoltaic power forecasting mostly relies on historical data and real-time weather prediction (NWP), and uses digital modeling to predict short-term photovoltaic power generation. The difficulty of distributed photovoltaic lies in the detection and discrimination of meteorological elements. [1, 2] At present, meteorological factors such as irradiance, temperature, wind direction, wind speed and humidity are currently selected as common influencing factors for photovoltaic power prediction modeling. In outdoor experiments, based on different environmental characteristics and output power, The analysis results show that the factor most positively correlated with power generation is irradiance, while the most negatively correlated factor is air humidity. The relevant charts are shown below. [3]

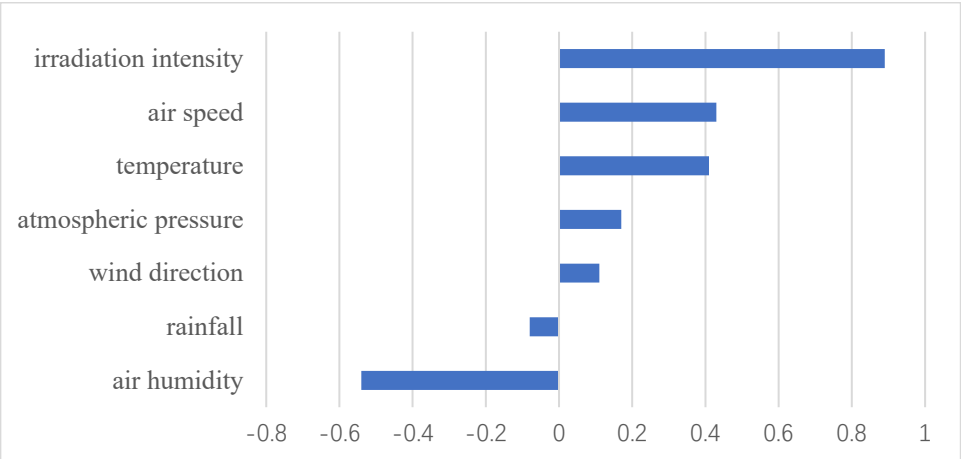


Figure 1. Factor affecting distributed photovoltaic power generation

3. Short-term Power Prediction Model

Due to the randomness and uncertainty of photovoltaic power generation, short-term prediction accuracy is not high. New modeling is needed to improve forecast accuracy. Currently widely used power prediction methods include direct prediction method and indirect prediction method. The direct prediction method can directly calculate the photovoltaic output value without considering the surrounding environment, and the modeling is relatively simple, so it has been widely used. The direct prediction method can build different models, such as time series models, Markov models, neural network models, and is widely used in short-term power prediction to obtain more accurate prediction results. But direct models require large amounts of history. Although the indirect prediction method does not rely on historical data, it requires understanding of local environmental parameters and geographical conditions in the prediction process to establish a model. The error tolerance rate is low, but compared with the direct prediction method, it can further ensure the accuracy of the prediction results.

3.1. Neural Network Model:

Neural network models include artificial neural networks, back-propagation neural networks, radial basis function neural networks, and recursive neural networks. These machine learning methods can be used for short-term photovoltaic power generation prediction. Neural network models generally use back-propagation neural networks. The learning ability of a neural network is often affected by the number of nodes and the number of training layers. The smaller the number of nodes and the fewer training layers, the worse its learning ability. People can increase the number of nodes and training layers to improve the accuracy of its predictions. However, if the number of nodes and training layers increases, the equipment requirements will increase. Affected by training time and difficulty, the accuracy of prediction cannot be guaranteed. In the forecasting process, the comprehensive calculation results of multiple forecasting methods are far better than a single forecasting method. At present, models jointly built by multiple algorithms are commonly used to achieve better performance in different operating units. When using neural networks, people must not only consider the local climate and environmental characteristics, but also consider the factors that affect solar power generation. Perform error optimization and parameter adjustment to ensure the accuracy of predictions. [4, 5] The following are several typical hybrid models:

3.1.1. CNN-LSTM Photovoltaic Power Prediction Model

Utilize Convolutional Neural Networks (CNN), which has high data processing capabilities, and Long Short-Term Memory, which has strong ability to process time sequences, to combine the two. In this method, the CNN part is responsible for extracting the features of the input data; the LSTM part is responsible for photovoltaic power prediction. The two parts are connected through the Repeat Vector layer. The LSTM part is converted into the corresponding output value through the Dense fully connected layer. The structure of the data model is as shown on the right. As shown in the figure: [6]

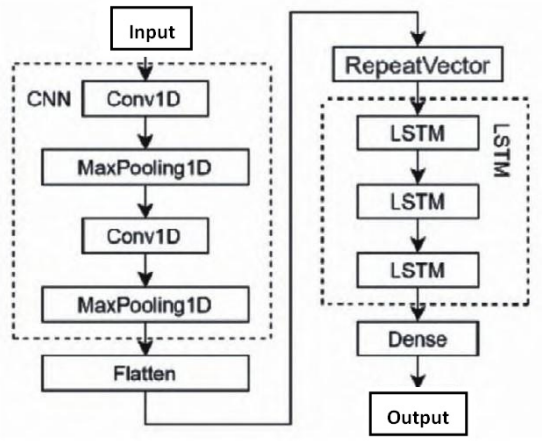


Figure 2. How CNN-LSTM work

On the basis of this model, a new prediction model is constructed to address relevant issues. For example, if the photovoltaic sequence is highly volatile and there is continuity in the photovoltaic sequence between adjacent days, SSA is used to decompose the photovoltaic output into relatively stable sub-sequences, perform data normalization processing, eliminate outliers and missing values, and then submit it to the C NN network for feature extraction. [7]

3.1.2. BP Neural Network Model

The BP neural network algorithm (Back Propagation) was established in the 1980s as a multi-layer forward transmission of signals and an algorithm that simultaneously transmits errors in the reverse direction. It is currently widely used in the field of power generation power prediction. Application. The basic principle is that in the process of signal forward transmission, the input signal acts on the output node through the hidden layer, and after calculation and analysis, the output signal is generated. If the actual output does not match the expected output, it will switch to the reverse direction of the error. communication process, modify the initial set weights, continue training iterations, and finally obtain the desired results. The basic composition is shown in the figure on the right: [8]

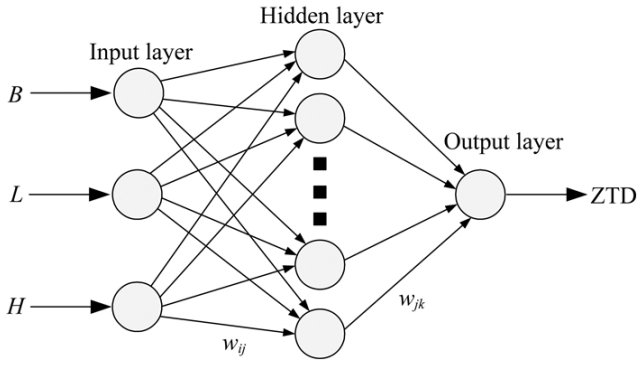


Figure 3. A typical BP neural network

There is great uncertainty in the selection of the initial threshold of the B P neural network, and it is easy to fall into the dilemma of local optimality. Its convergence speed is also relatively slow, and it cannot achieve the ideal accuracy and speed. Therefore, it is necessary to process the data in advance and make certain improvements to the B P neural network. The B AS algorithm, particle swarm algorithm, etc. can be used for data preprocessing to overcome the limitations of the

B P neural network in initial threshold selection and obtain better results. Good initial weights improve the accuracy of the system.

3.1.3. RNN Neural Network Model

The R NN neural network not only contains the input of the previous moment, but also contains a memory function, that is, the neural network will store the frontline information and use it in the current calculation. Compared with the traditional neural network, the R NN Neurons have directionality, so that RNN has more dimensional information, can process higher-dimensional data, and has a good effect on nonlinear high-dimensional function approximation. Therefore, it is used in the prediction of short-term photovoltaic power generation.

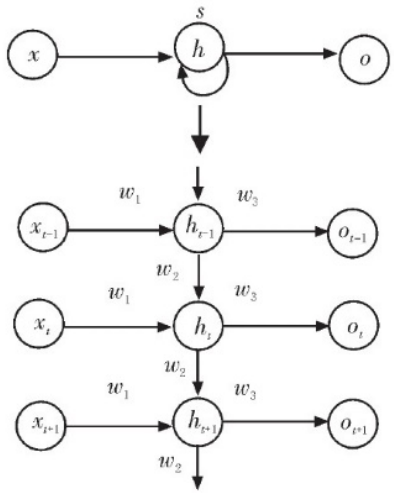


Figure 4. RNN neural network model

of a single RNN neural network during the training process, there will be large errors during the training process and sufficient accuracy cannot be guaranteed. The acquired data also needs to be processed. The inertia weight is used to add the restraint amount to improve System accuracy.

3.2. Markov Model

The Markov model is a mathematical model of the change process between discrete states of an event object. It is instantaneous, that is, the state of the moment to be predicted is only determined by the state of its adjacent previous moment and has nothing to do with other moments. The photovoltaic power sequence can be regarded as a transition process between different states, so the Markov chain model can predict the power change trend and the probability that the power value is in different state intervals at the time to be predicted. The traditional Markov chain model has certain limitations and cannot cope with complex changes in the prediction process when the curve change rate suddenly changes and the numerical value fluctuates violently. [9, 10]

3.3. Time Series Model

People regard the data to be analyzed as a completely irregular random process, thereby establishing a model to obtain the observed values of the time series under past and future observation conditions, and obtain from regression model, moving average model, cumulative autoregressive and autoregressive integrated moving average model (auto regressive integrated moving average ARIMA). Its working principle is to remove the inherent global trend component of the solar power generation system on similar days, obtain the remaining component, and establish the above autoregressive moving average models. The prediction residual component and the inherent global trend component are accumulated to obtain the final prediction value of photovoltaic power generation. The currently widely used time series model does not require equidistant divisions of data and has a faster processing speed. Currently, it has received positive feedback, [11] time The sequence model better considers the correlation of each group of data and improves the validity of the data. [12]

4. Indirect Prediction Method

The indirect prediction method uses meteorological data, photovoltaic power generation equipment and other parameters to conduct data modeling of the entire system to obtain the predicted power. Solar irradiation is the most important factor affecting solar power generation, so most indirect prediction models are based on solar radiation. Modeling of irradiation intensity. For obtaining prediction data of irradiation intensity, the prediction method based on weather forecast is better than other statistical methods [13] . At present, the widely used indirect prediction method includes the method based on power generation. The principal prediction method for prediction and the expert system prediction method are based on the historical data of different periods in the database and based on the experience of photovoltaic prediction experts.

5. Summary and Expectations

With the gradual development of solar photovoltaic power generation, the prediction of short-term power generation gradually plays a more important role. At present, many data models have been proposed, providing more theoretical support for short-term photovoltaic power prediction. Combination forecasting methods are often used to establish new models for forecasting analysis. Currently, existing methods generally have timeliness and universal applicability issues, and further experimental data are needed to improve them. At the same time, the prediction performance under complex weather conditions also needs to be enhanced. Hybrid models gradually replace single models and improve prediction accuracy. However, the complexity of the model increases significantly.

Future research focuses on photovoltaic power generation include:

(1) Research and development of more hybrid models

(2) Strengthen the application of artificial intelligence and machine learning in indirect prediction.

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