LITERATURE SURVEY

PREDICTING THE ENERGY OUTPUT OF WIND TURBINE BASED ON WEATHER CONDITION

[1] Multi-step wind speed and power forecasts based on a WRF simulation and an optimized association method

Author Name: Xia-Xiao, Jianzhou-Wang, Dezhong-Chi.

At present, operational power forecasts are primarily based on the predicted wind speed of a single-valued deterministic Numerical Weather Prediction (NWP) simulation. However, due to the unavoidable uncertainties from model initialization and/or model imperfections, recent numerical techniques cannot directly meet the actual needs of grid dispatch in many cases, which means that achieving accurate forecasts of wind speed and power is still a critical issue. On this topic, our paper contributes to the development of a new multi-step forecasting method termed CSFC-Apriori-WRF, providing a one-day ahead wind speed and power forecast consisting of 96 steps. This method is based on a Weather Research and Forecasting (WRF) simulation, a Cuckoo search (CS) optimized fuzzy clustering, and an Apriori association process. First, a wind speed forecast is generated by running a configured WRF model. Next, the wind speed forecasting series is divided into segments that meet certain conditions and are defined as "waves" in this paper. Next, combining the CS-optimized fuzzy clustering and Apriori algorithm, the proposed method extracts the association rules between the shape characteristics and the forecasting error of the divided waves. Applying the association rules in the final optimization process, the proposed method significantly reduces the uncertainties of the WRF simulation and performs best among other models to which it is compared.

[2] A hybrid technique for short-term wind speed prediction

Author Name: Jianming-Hu, Jianzhou-Wang, Kailiang-Ma

This study proposes a hybrid forecasting approach that consists of the EWT (Empirical Wavelet Transform), CSA (Coupled Simulated Annealing) and LSSVM (Least Square Support Vector Machine) for enhancing the accuracy of short-term wind speed forecasting. The EWT is employed to extract true information from a short-term wind speed series, and the LSSVM, which optimizes the parameters using a CSA algorithm, is used as the predictor to provide the final forecast. Moreover, this study uses a rolling operation method in the prediction processes, including one-step and multi-step predictions, which can adaptively tune the parameters of the LSSVM to respond quickly to wind speed changes. The proposed hybrid model is demonstrated to forecast a mean half-hour wind speed series obtained from a windmill farm located in northwestern China. The simulation results suggest that the developed forecasting method yields better predictions compared with those of other popular models, which indicates that the hybrid method exhibits stronger forecasting ability.

[3] A Multi-Step Prediction Method for Wind Power Based on Improved TCN to Correct Cumulative Error

Author Name: Heifeng luo, Xun dou, Rong sun

Wind power generation is likely to hinder the safe and stable operations of power systems for its irregularity, intermittency, and non-smoothness. Since wind power is continuously connected to power systems, the step length required for predicting wind power is increasingly extended, thereby causing an increasing cumulative error. Correcting the cumulative error to predict wind power in multistep is an urgent problem that needs to be solved. In this study, a multi-step wind power prediction method was proposed by exploiting improved TCN to correct the cumulative error. First, multi-scale convolution (MSC) and self-attentiveness (SA) were adopted to optimize the problem that a single-scale convolution kernel of TCN is difficult to extract temporal and spatial features at different scales of the input sequence. The MSC-SA-TCN model was built to recognize and extract different features exhibited by the input sequence to improve the accuracy and stability of the single-step prediction of wind power. On that basis, the multichannel time convolutional network with multiple input and multiple output codec technologies was adopted to build the nonlinear mapping between the output and input of the TCN multi-step prediction. The method improved the problem that a single TCN is difficult to tap the different nonlinear relationships between the multistep prediction output and the fixed input. The MMED-TCN multi-step wind power prediction model was developed to separate linearity and nonlinearity between input and output to reduce the multi-step prediction error. An experimental comparative analysis was conducted based on the measured data from two wind farms in Shuangzitai, Liaoning, and Keqi, Inner Mongolia. As revealed from the results, the MAE and RMSE of the MMED-TCN-based multi-step prediction model achieved the cumulative mean values of 0.0737 and 0.1018. The MAE and RMSE metrics outperformed those of the VMD-AMS-TCN and MSC-SA-TCN models. It can be seen that the wind power prediction method proposed in this study could improve the feature extraction ability of TCN for input sequences and the ability of mining the mapping relationship between multiple inputs and multiple outputs. The method is superior in terms of the accuracy and stability of wind power prediction.

[4] Remotely Sensed Winds and Wind Stresses for Marine Forecasting and Ocean Modeling

Author Name: Mark A. Bourassa, Thomas Meissner, Ivana Cerovecki.

This paper is focused on remotely sensed surface winds (scalar winds and vector winds) with related material on surface stress, air-sea heat fluxes, currents, sea state, and precipitation. It begins with definitions used in the description of remotely sensed winds followed by a description of wind sensing techniques including strengths, weaknesses, spatial coverage, and resolution (section Observation Technologies and Networks). Planned and suggested improvements to these observations are also discussed. Three of the largest concerns with modern observations are rain contamination (section Rain Contamination), calibration at very high wind speeds (section High Wind Speed retrieval) and the lack of observations near land and ice. Section Multi-Satellite Wind Products is a brief description of merged satellite products that are produced on a regular grid.

The connections between observing system governance (section Observing System Governance), science teams and users, and data centers (section Data and Information Systems) are explained. This is followed by sections on applications, with the greatest detail provided on operations (section Hazards and Marine Safety) and discovery (section Discovery), and the requirements for these applications. The last section is a summary of key issues and requirements.

[5] Wind Generation Forecasting Methods and Proliferation of Artificial Neural Network

Author Name: Muhammad Shahzad Nazir, Fahad Alturise, Sami Alshmrany.

To sustain a clean environment by reducing fossil fuels-based energies and increasing the integration of renewable-based energy sources, i.e., wind and solar power, have become the national policy for many countries. The increasing demand for renewable energy sources, such as wind, has created interest in the economic and technical issues related to the integration into the power grids. Having an intermittent nature and wind generation forecasting is a crucial aspect of ensuring the optimum grid control and design in power plants. Accurate forecasting provides essential information to empower grid operators and system designers in generating an optimal wind power plant, and to balance the power supply and demand. In this paper, we present an extensive review of wind forecasting methods and the artificial neural network (ANN) prolific in this regard. The instrument used to measure wind assimilation is analyzed and discussed, accurately, in studies that were published from May 1st, 2014 to May 1st, 2018. The results of the review demonstrate the increased application of ANN into wind power generation forecasting. Considering the component limitation of other systems, the trend of deploying the ANN and its hybrid systems are more attractive than other individual methods. The review further revealed that high forecasting accuracy could be achieved through proper handling and calibration of the windforecasting instrument and method.

[6] Long term wind power forecast using adaptive wavelet neural network

Author Name: Bhaskar-Kanna, Sn-Singh.

With the growing uncertainty due to high wind power penetration, an accurate wind power forecast tool is very much essential for economic and stable operation of the electricity markets. It helps the system operators, to include wind generation into economic scheduling, unit commitment and reserve allocation problems. It also assists the wind power producers to minimize their losses through strategic bidding in the day ahead electricity markets. In this paper the problem of long-term wind power forecast is addressed, considering the numerical weather prediction (NWP) system wind speed and wind direction forecasts as inputs. An adaptive wavelet neural network is proposed for mapping the NWP's wind speed and wind direction forecasts to wind power forecasts. Wind direction inheritantly being a circular variable, for better training and function approximation, a transformed version of wind direction variables are used as inputs. Further, a closest set of patterns based on euclidean distance are chosen for training patterns and block wise training and forecast strategy is employed for carrying wind power forecast. The results show that the significant improvement over persistence method is achieved.

[7] AWNN-Assisted Wind Power Forecasting Using Feed-Forward Neural Network

Author Name: Bhaskar-Kanna, Sn-Singh.

With the growing wind power penetration in the emerging power system, an accurate wind power forecasting method is very much essential, to help the system operators, to include wind generation into economic scheduling, unit commitment, and reserve allocation problems. It also assists the wind power producers to maximize their benefits by bidding in the electricity markets. A statistical-based wind power forecasting without using numerical weather prediction (NWP) inputs is carried out in this work. The proposed approach consists of two stages. In stageI, wavelet decomposition of wind series is carried out and adaptive wavelet neural network (AWNN) is used to regress upon each decomposed signal, to predict wind speed up to 30 h ahead. In stage-II, a feed-forward neural network (FFNN) is used for nonlinear mapping between wind speed and wind power output, which transforms the forecasted wind speed into wind power prediction. The effectiveness of the proposed method is compared with persistence (PER) and newreference (NR) benchmark models and the results show that the proposed model outperforms the benchmark models.

[8] Wind Speed Forecasting using MRA based Adaptive Wavelet Neural Network

Author Name: K. Bhaskar, S.N. Singh.

This paper addresses the problem of predicting hourly wind speed using Adaptive Wavelet Neural Networks (AWNN). It employs wavelets as its activation function in the hidden layer. Due to time-frequency localiztion property and adapting the wavelet shape according to training data set instead of adapting the parameters of the fixed shape basis function, WNNs have better generalization properties in contrast to the classical Feed Forward Neural Network (FFNN). The wavelet based multiresolution analysis (MRA) is applied on wind series to decompose in to smooth and detail signals for better wind characterization and reliable forecasting. The transformed data of historical wind series were trained and tested over various periods of time using AWNNs. The forecasting results are better when compared with AWNN as a forecasitng model alone, FFNN with Back Propagation (BP) training algorithm as a forecasting model, and MRA based FFNN as a forecasting model.

[9] Enhancing Wind Turbine Power Forecast via Convolutional Neural Network

Author Name: Tianyang Liu, Zunkai Huang, Li Tian.

The rapid development in wind power comes with new technical challenges. Reliable and accurate wind power forecast is of considerable significance to the electricity system’s daily dispatching and production. Traditional forecast methods usually utilize wind speed and turbine parameters as the model inputs. However, they are not sufficient to account for complex weather variability and the various wind turbine features in the real world. Inspired by the excellent performance of convolutional neural networks (CNN) in computer vision, we propose a novel approach to predicting short-term wind power by converting time series into images and exploit a CNN to analyze them. In our approach, we first propose two transformation methods to map wind speed and precipitation data time series into image matrices. After integrating multi-dimensional information and extracting features, we design a novel CNN framework to forecast 24-h wind turbine power. Our method is implemented on the Keras deep learning platform and tested on 10 sets of 3-year wind turbine data from Hangzhou, China. The superior performance of the proposed method is demonstrated through comparisons using state-of-theart techniques in wind turbine power forecasting.

[10] A Forecasting Model of Wind Power Based on IPSO–LSTM and Classified Fusion

Author Name: Qiuhong Huang and Xiao Wang

To improve the predicting accuracy of wind power, this paper proposes a forecasting model of wind power based on the IPSO–LSTM model and classified fusion, which not only overcomes the shortcoming of the artificially determined parameters of LSTM, but also solves the problem that the fused accuracy may be reduced by the environment when adopting a single fusion model. Firstly, some wind speed sub-series were obtained by decomposing the original wind speed according to the wavelet packet decomposition (WPD), and the data sets formed by combining these sub-series with meteorological elements. Subsequently, the wind power components formed by wind speed decomposition are predicted through the long short-term memory neural network (LSTM), which is optimized by the improved particle swarm optimization (IPSO). Consequently, the predicting value of the final wind power was acquired by adopting the method of classified fusion to calculate the wind power components. Several case studies were carried out on the proposed model with the help of Python. It is found from those relevant results that the RMSE and MAE of the proposed model is 1.2382 and 0.8210, respectively. Moreover, the R2 is 0.9952. Those simulating results show that the proposed model may be better for fitting the actual curve of wind power and has excellent predicting accuracy.

[11] Data mining for wind power forecasting

Author Name: Lionel-Fugon, George-Kariniotakis, Jeremie-Juban.

Short-term forecasting of wind energy production up to 2-3 days ahead is recognized as a major contribution for reliable large-scale wind power integration. Increasing the value of wind generation through the improvement of prediction systems performance is recognised as one of the priorities in wind energy research needs for the coming years. This paper aims to evaluate Data Mining type of models for wind power forecasting. Models that are examined include neural networks, support vector machines, the recently proposed regression trees approach, and others. Evaluation results are presented for several real wind farms.

[12] Wind Power Generation Prediction Using Machine Learning Algorithms

Author Name: Ozlem Ece Yurek, Derya Birant, Ismail Yurek.

Renewable energy becomes progressively popular in the world because renewable resources such as solar, geothermal, wind energy are clean, inexhaustible and come from natural sources. Wind energy is one of the most significant resources of renewable energy and it plays a key role in the generation of electricity. Thus, accurate wind power estimation is crucial to deal with the challenges to balance energy trading, planning, scheduling decisions and strategies of wind power generation. This study proposes a prediction model to solve a real-life problem in the renewable energy sector by accurately estimating the amount of wind energy production per hour in the next 24 hours by applying machine learning (ML) techniques using historical wind power generation data and weather forecasting reports. In the proposed approach, first, an unsupervised ML method (i.e., the KMeans clustering algorithm) is applied to group data into meaningful clusters; then, these clusters are accepted as new feature values and added to the dataset to enlarge it; finally, a supervised ML method (i.e., regression) is performed for prediction. This study compares nine supervised learning algorithms: K-Nearest Neighbors, Support Vector Regression, Random Forest, Extra Trees, Gradient

Boosting, Ridge Regression, Least Absolute Shrinkage and Selection Operator, Decision Tree, and Convolutional Neural Network. The aim of this study is to investigate the success of different ML algorithms on real-world data of wind turbines and propose a methodology to benchmark various machine learning algorithms to choose the most accurate final model for wind power generation prediction.

[13] Wind Power Prediction based on Random Forests

Author Name: Zehong Zhou, Xiaohui Li, Huaren Wu.

With a massive increase of wind power, the prediction of wind power is becoming increasingly important. The algorithm of Random forests has many advantages such as less adjustable parameters, higher precision of prediction and better generalization ability. This algorithm has been widely applied in numerous fields such as medical science, management and economics. However there is no application in short-term wind power prediction yet. In this paper, the random forest algorithm will be applied to the short-term wind power prediction. The random forest regression model is established. The powers of a wind farm are predicted. The effectiveness of random forest regression algorithm adopted is verified in wind power prediction.