Case Study

Analytics Zoo
Artificial Intelligence
New Energy

Goldwind SE Builds Advanced Intelligent Power Prediction Solution for New Energies Based on Analytics Zoo

GOLDWIND SE 金风慧能 | Smart Energy Services 智慧能源服务

Growing acceptance of clean energy concepts has led to renewable energies such as wind power and photovoltaics (PV) playing an increasingly important role in the energy sector. Data from China's National Energy Administration (NEA) showed that wind power production nationwide in the first half of 2019 grew by 11.5% year-on-year, with installed PV capacity increasing by 20%[1].

Unlike conventional energy sources, new energies such as wind and PV are greatly impacted by environmental factors. The random and variable nature of wind and sunlight create tough challenges for grid stability and safety. Recent years have seen increased adoption of emerging technologies such as artificial intelligence (AI), Internet of Things (IoT), and cloud computing by the new energy industry. It can be seen that smart techniques are being applied to solve the above challenges and will become the preferred choice for new energy enterprises seeking to take the lead in future green energy development.

Aiming to lead the way in new energy digitalization and intelligence, Beijing Goldwind Smart Energy Services Co., Ltd. ("Goldwind SE") is committed to developing new energy IoT systems and solutions, and is one of the important pioneers on the path to green energy. Goldwind SE is combining deep learning and machine learning with data from turbine-level weather forecasting and wind trajectory simulation to develop an innovative smart power prediction solution based on multi-model integration. For this purpose, the company has established a close partnership with Intel to build a distributed architecture based on Analytics Zoo, Intel's unified big data analytics and AI platform. This distributed architecture encompasses everything from feature engineering, capture of impact factors on predictions, multi-model integration, and customized policy updates. Optimizations were also made for time-series nature of prediction data. The innovative solution co-developed by Goldwind SE and Intel has been subsequently validated through a series of field tests and has since been applied with satisfactory results.

"Goldwind SE has always focused on the integration of cutting-edge information technology (IT) with developments in the new energy sector to provide users with more efficient and agile solutions. The united end-to-end architecture and advantages in time series data analysis provided by Analytics Zoo has made our multi-model integration solution for power prediction using weather forecasting data faster and easier to deploy. Prediction accuracy and stability have also been significantly improved."

Zhang Li
Chief Architect
Goldwind SE

Advantages of the Goldwind SE Innovative Smart Power Prediction Solution

- The innovative multi-model solution integrates weather forecasting data and offers enhanced support from time series data, providing higher prediction accuracy and stability than traditional solutions.
- Analytics Zoo, Intel's unified big data analytics and AI platform, provides a unified end-to-end distribution solution. The new solution can help users improve the system's development and deployment efficiency and scalability, while reducing hardware, operation and maintenance costs.
- Analytics Zoo's unique functions and advantages for time series data analysis improve prediction performance, enabling better fitting of the prediction model and the actual power output.

Clean renewable energies such as wind and PV are becoming increasingly popular. However, environmental factors such as wind speed, wind direction, sunlight, temperature, and air pressure during the power generation process all have major impacts on power systems. This results in challenges for generation equipment and connected grids in terms of operational efficiency and equipment safety. Therefore, predicting the power output from new energy sources helps the dispatching system regulate and optimize power generation plans and improve peak regulation capability. Such predictions also help reduce wind/PV curtailment and lower operating costs so as to enhance the competitiveness of power enterprises.

Historical data and human experience have been traditionally used by energy companies to predict power generation. This approach is marred with issues, including low accuracy and high volatility. Advances in IT have led to growing application of informationized and digitized prediction methods in power prediction. The increased availability of AI algorithms and greater computing power support has made it possible to implement AI-based prediction methods that leverage historical big data. Support Vector Machine (SVM) and Multi-Layer Perceptron (MLP), for example, have been proven to effectively improve the operating efficiency of power systems.

With its extensive experience in smart power prediction, Goldwind SE believes that existing AI prediction methods can be optimized even further. On one hand, there is still room for improvement in both the accuracy and stability of singular deep learning and machine learning methods. On the other hand, power enterprises are facing IT challenges during a series of model building processes such as feature engineering and short-term/ultra-short-term online/offline training etc. involved in prediction systems. Goldwind SE is eager to introduce new technologies and construct a next generation smart power prediction solution, which is more accurate and easier to deploy, for industry users.

Integrated Multi-Model Power Prediction Solution with Weather Forecasting Data

The smart power prediction process is generally split into modules for edge data collection, storage, governance, inference, and AI training. As shown in Figure 1, the edge sensors deployed at the wind turbine and PV inverter (on the far left of this figure) transmit comprehensive environmental and operational data such as wind speed, temperature, power, and electricity output to the data center for storage. The data is then screened for validity using the data governance module. An appropriate deep learning or machine learning framework is then used to combine the filtered data with historical data for training and inference. The resulting model is used to map the relationships between environmental factors and power, power and power, and output and power over a certain amount of time.

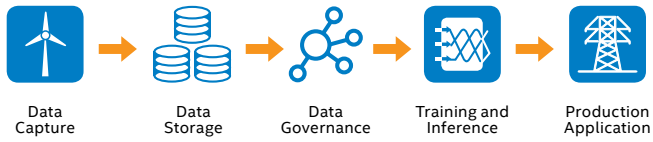

Figure 1 Traditional AI power prediction process

It can be seen that traditional AI power prediction utilizes a single AI algorithm model to carry out training and inference on data samples for environmental parameters, power, and output. While this approach may provide accurate predictions for relatively short period (within the next 15-30 minutes), prediction accuracy drops off as the lead time increases. Even the ultra-short-term predictions that are most often used in power prediction systems for power generation need to cover the power output for the next 4 hours. In other words, prediction systems must maintain a high level of accuracy and stability for the next 16 time points (15 minutes = 1 time point).

Through research and tests, Goldwind SE found that the prediction accuracy and stability could be effectively improved by introducing just two technologies into the existing smart prediction systems. The first step is to integrate weather forecasting into power prediction systems. As the traditional approach uses existing power data to predict future power output, time series data was lacking. Weather forecasting data effectively makes up for this shortfall with time series data that ensures consistent prediction accuracy for each future time point. The other technology introduced is multi-model integration. That means different deep learning or machine learning models are selected and combined with weather forecasting data according to actual needs to increase system prediction accuracy.

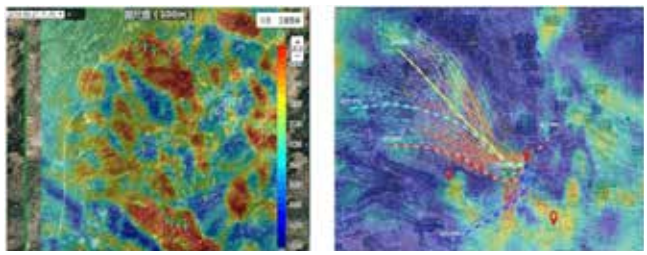

Figure 2 Turbine-level weather forecasting and wind trajectory simulation

Power prediction also requires highly exact parameters and metrics from weather forecasting data, including fine spatial resolution, qualitative and quantitative feature analysis, and stable forecasting accuracy. To ensure stability and accuracy of the new solution through combined forecasts, Goldwind SE partnered with authoritative institutions such as the China Meteorological Administration (CMA) and the European Centre for Medium-Range Weather Forecasts (ECMWF). As shown in Figure 2, the scale of turbine-level weather forecasting (left) was refined from the standard 9 km to a micro scale of 100 m. Wind trajectory simulation (right) is now capable of quantitative analysis of actual wind paths.

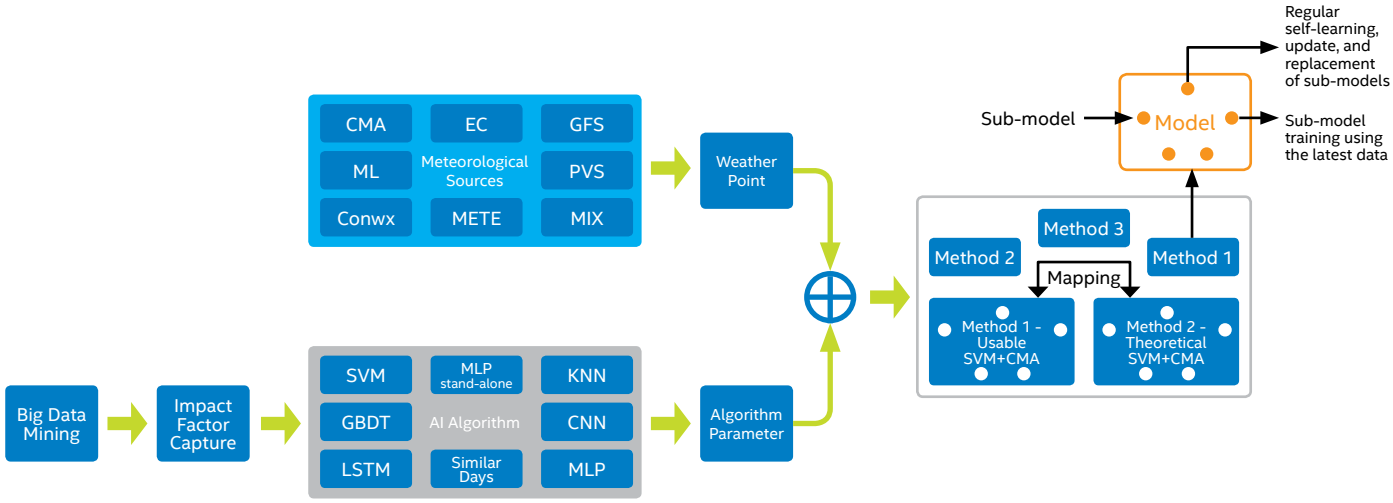

Figure 3 Architecture of integrated multi-model prediction solution with weather forecasting data

The inclusion of high-quality weather forecasting data allowed Goldwind SE to build a prediction solution based on multi-model integration. The solution starts by mining big data for feature engineering and to capture prediction impact factors such as wind speed, wind direction, and temperature. As shown in Figure 3, weather forecasting data from different sources such as CMA and the ECMWF are combined with parameters provided by multiple deep learning and machine learning algorithms into a new method such as SVM+CMA.

The new solution can provide various other combinations as needed. The algorithmic models of each combination can continue to train its sub-models using the latest data. These sub-models can then undergo regular self-learning, updates, and replacement to increase prediction system accuracy through continuous iterations.

Building a Distributed Power Prediction Architecture using Analytics Zoo

The incorporation of weather forecasting data is the key advantage of Goldwind SE's new solution. It is widely understood that weather forecasting data is a classic example of time series data as its data values change over time. Choosing a system architecture more suited to processing time series data naturally increases the accuracy and stability of the prediction system. It is here that Analytics Zoo, Intel's unified big data analytics and AI platform, provides a unified end-to-end distributed solution that improves the system efficiency and scalability in both development and deployment. Its unique functionality and advantages in time series data analytics offers significant boosts to new solutions as well.

Analytics Zoo is a fusion of Intel's innovations in big data analytics and AI. As shown in Figure 4, it helps Goldwind SE integrate Spark*, TensorFlow*, Keras* and other software and frameworks used in its new solution into a single pipeline. This approach helps Goldwind SE integrate all data storage, data processing, training, and inference processes into a unified infrastructure, greatly improving the deployment efficiency, resource utilization, and scalability of its new solution while reducing hardware management and system maintenance costs.

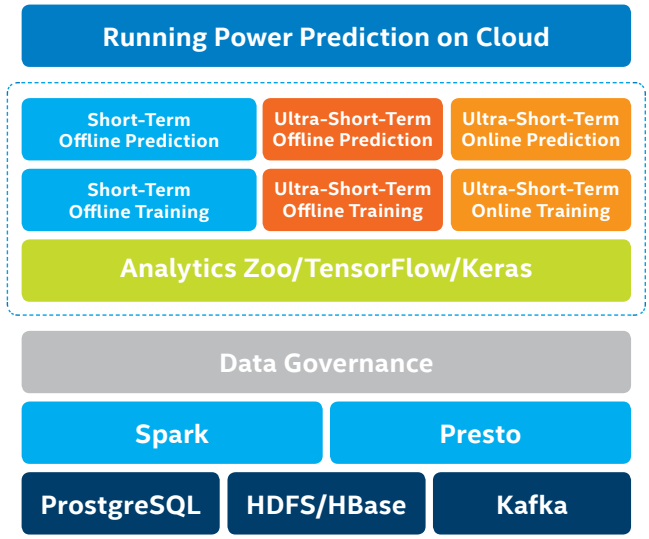

Figure 4 Distributed power prediction architecture based on Analytics Zoo

Analytics Zoo is also capable of making effective use of the many underlying software accelerator libraries offered by Intel, such as Intel® Math Kernel Library (Intel® MKL), and Intel® Math Kernel Library for Deep Neural Network (Intel® MKL-DNN), providing further optimization to the upper-layer power prediction solution. TensorFlow and Keras models can be transparently expanded to big data clusters to improve the ease in which users can utilize distributed architecture in their training or inference solution for further enhancement.

In addition to its unified end-to-end platform architecture, the primary advantage provided by Analytics Zoo is its range of functions and features for time series data

analysis. Analytics Zoo provides complete solutions for different time series analysis applications such as time series prediction, anomaly detection, feature learning, and clustering, allowing Goldwind SE to easily introduce more combinations of prediction methods to its new solution. Analytics Zoo also offers an extensive array of pre-configured components for time series data.

- Common deep learning and machine learning models for power prediction: LSTM, Encoder-Decoder, MtNet, ARIMA, etc.
- Common data pre-processing and feature engineering methods for power prediction: Datetime features, Time diff, Log-transform, Rolling window, etc.
- Common anomaly detection methods for power prediction: Percentile, Distribution-based, Uncertainty based, Autoencoder, etc.

In addition to the above components, Analytics Zoo also provided the new solution with AutoML (Automated Machine Learning) methods for automated feature selection, model selection, and hyper parameter optimization. This improves the ability of the prediction model to fit variation period of power output.

Goldwind SE and Intel conducted field trials at a number of PV test sites throughout the country to validate the new distributed power prediction solution based on Analytics Zoo. The validation program used a monthly cycle. In each PV test site, 30,000 records in one hour were used to perform 5,000 times of iterative optimizations for LSTNet model and the power prediction data for the next 2 hours was then returned within 50ms. The validation outcomes seen in Figure 5 show that the prediction accuracy of the new solution reached 79.41%[2], a 20% increase over the 59% accuracy of the old solution.

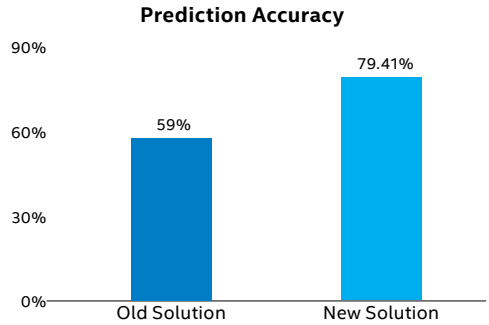

Figure 5 Comparison of new and old solutions

Looking Ahead: From Industry-Leading Innovation to Accelerated Implementation

By collaborating with Intel, Goldwind SE has developed an innovative, ultra-refined smart power prediction solution with high performance and accuracy. Work has now begun on implementing the practice. Goldwind SE's data showed that introducing this enhanced AI prediction solution to wind farms can help power enterprises improve their generation efficiency and improve the feasibility of environmentally friendly, green energy.

Intel and Goldwind SE are planning to engage in more extensive and in-depth collaboration on the development of smart power prediction solutions for new energy in the future. Goldwind SE hopes to develop a complete data governance platform based on Analytics Zoo for data optimization. Both companies also plan to expand the validation of the new solution to 100 PV sites and wind power prediction applications to obtain further data and develop more optimized models and solutions. This will provide users with high-quality and high-availability smart power prediction systems for new energy, and serve as another example of innovative integration of IT and green energy technology.

[1] Data Cited from the report by China's National Energy Administration: http://www.nea.gov.cn/2019-07/26/c_138259422.htm, http://www.nea.gov.cn/2019-08/23/c_138330885.htm

[2] Testing Configuration: Processor: Intel® Xeon® Gold 6130 processors Memory: 192GB DDR4 2666MHz Operating system: CentOS 7.6 Spark Version: 2.4.3, please contact Goldwind SE for further details.