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Short Communication

Informatization process of wind and solar resource power generation: Empirical abstraction and packing algorithm

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Keywords: Wind and solar resource generation industry; Observation data management platform; Software tool of wind turbine arrangement; A hybrid deep network model for simulation data

Abstract

The development of software tools is critical to meeting the changing needs of the wind and solar resource generation industries. By identifying some of the limitations of existing systems, such as fragmentation in data query and plant management, as well as a lack of data resource management. In response to these issues, it is proposed to use a hybrid deep network model for simulation data to develop a management platform for wind and solar resource observation data. High-quality real-time measurement data and standardized data processing can be collected stably using these tools, which can significantly improve the development efficiency of landscape resource power generation projects and save development costs.

Wind and solar resources power generation information status quo

As a new type of pollution-free energy with large reserves, wind, and solar resources have huge potential energy. With the environmental protection concept of green development and low-carbon emission reduction, the use of photovoltaic and wind power generation based on local conditions is very consistent. Therefore, international concern is increasing [1].

People have done a lot of exploration work in the field of wind and solar resource power generation design using software tools. For example, resource data query functions, batch data processing schemes, power station design algorithms, and so on. In recent years, many achievements have been made to promote the progress of the industry, but there are numerous deficiencies still [2].

In common systems for data querying, a single source of truth is provided, and multiple data sources cannot be used for comparative reference at the same time, resulting in limitations in the perspective of resource data judgment. A single source of truth is provided in common systems for data querying, and multiple data sources cannot be used for comparative reference at the same time, resulting in limitations in the perspective of resource data judgment. With the wide range of professional knowledge involved in the design process of power stations, engineering measurement methods often rely on the experience and ability of engineers. Therefore, the completion of procedural and algorithmic design processes still requires more industry consensus and experience summaries [3,4]. The functions of the completed power station management system are relatively independent, and there is a lack of data management for each stage before the completion of the power station, which cannot achieve the full life cycle management of the project, leading to problems such as difficulty in reconciling existing projects and difficulty in improving cognition. Which

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cannot realize the whole life cycle management of the project, leading to the problems of difficult review and difficult cognitive enhancement of the existing project [5].

In conclusion, considering the current high demand of the new energy generation industry for online resource data sharing management, semi-automated power plant design, and integrated power plant information management, and based on the above existing problems, providing software tools that are more in line with the industry development trend and user application scenarios has become an urgent need.

Simulation model of wind and solar resource data

Wind and solar resource simulation data are decisive factors in the initial stage of the project, and we strive to provide strong underlying data support. The system is compatible and displays multiple sets of underlying data simultaneously [6]. Source data 1 from the industry's authoritative database of high-precision resource data, source data 2 from the high-precision resource database produced by the hybrid deep network model composed of convolutional neural networks and multilayer perceptron. During the data simulation process, a large amount of measured data is used to train and calibrate the hybrid depth network in order to obtain an accurate simulation model [7,8].

Application example: Solarwind Scenic Resource Data Online Search Platform, provides multiple resource query tools based on the above high-quality underlying data, supporting engineers to quickly find geographical regions with superior resources and quickly estimate the power generation hours based on current resource conditions through the single point power generation calculation function. This significantly enhances the working efficiency of engineers while cutting the cost of project development time Figure 1.

As shown in the figure above, the data set generation and analysis output process are divided into 1-8 eight steps:

1. Prepare training sets.
2. Simulate the state at the top of Mt.
3. Initialize the deep network.
4. Train deep network for Rs estimation.
5. Fine-tune the preserved model in 4) for Rdif estimation.
6. Generate spatially continuous hourly estimation.
7. Integrate daily and monthly estimates.
8. Validate radiation datasets.

Wind and solar resource observation data management platform

Stable collection of high-quality real-time measurement data and standardized data processing are two ways to improve project development efficiency. For this purpose, we developed EasyData, a wind and solar resource observation data management platform. The platform takes wind measurement and photometric data management as the core,

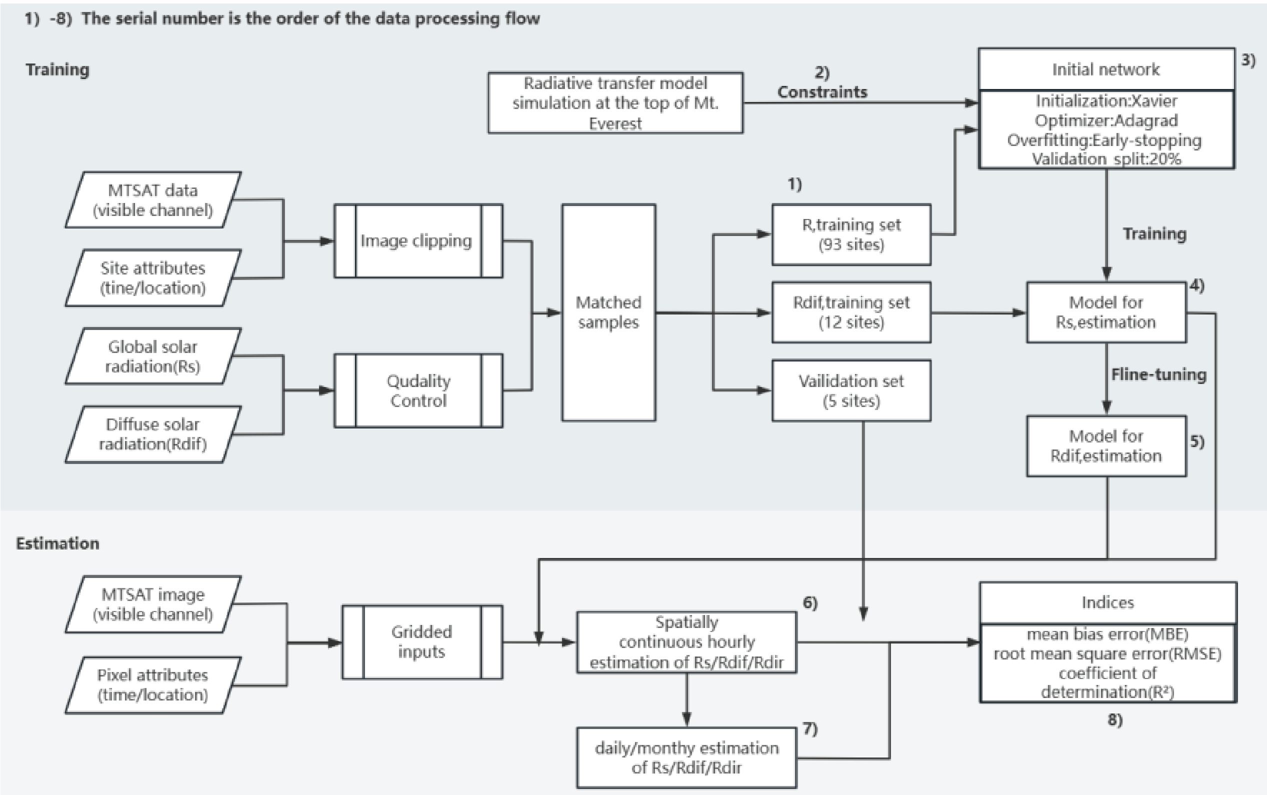

Figure 1: Hybrid deep network model assimilation and simulation of data processes [9].

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with automatic data pulling, data monitoring, and alarming, automatic data quality control, online data visualization, data report generation, and both data processing functions [10], Our product designers designed EasyData's data monitoring logic through experience summary, as shown in Figure 2 . Real-time monitoring of the quality and stability of the measured data and timely handling of potential risks in the data collection process can effectively improve the data integrity rate and enhance the value of data utilization. Supports multi-person co-creation collaboration for standardized data processing, including tower shadow correction, data interpolation, representative year correction, etc. It avoids the evaluation differences caused by the calculation habits of different data processors and also allows the measured data of different projects to be compared horizontally to generate more utilization value.

Explanation of nouns:

1. Out-of-warranty: If the current date is outside the warranty date range;
2. Outside management: Current date is within the warranty date, but site Data Management is set to No;
3. Warranty Period: If the current date is in the warranty date range, and site Date Management is set to Yes.
4. The site in the Warranty Period contains the status in 4;
5. Alarming: When the current status of the site is not "Ongoing focus" or "Repairing", but there is an unprocessed alarm;
6. Ongoing focus: When the current state of the site is not "Repairing", when an alarm is processed as "data abnormal, focus on";
7. Repairing: When handling the site alarm, process an alarm as "abnormal data, repair";
8. Normal: When the status of the site is not "Ongoing focus" or "Repairing" and not "Alarming".

Packing algorithm of the wind turbine arrangement

New energy power plant project design work involves a wide range of content and requires the cooperation of multiple design disciplines such as wind turbine arrangement, lifting platform, collector lines, boost station site selection, and design plan estimates [11]. Taking wind turbine arrangement as an example, the system can establish a comprehensive index evaluation system based on various factors such as altitude, slope, curvature, etc., ranking the effective layout points. Then, further, select the points that meet the minimum elliptical wind turbine spacing requirements one by one from high to low, and gradually occupy the higher-scoring positions. Automate wind turbine placement with this algorithm, and supports users to adjust the algorithm placement within a reasonable range based on experience [12,13], Its algorithm execution process is shown in Figure 3. And further on the basis of the algorithm using AI to optimize turbine design and site layout. As mentioned above, the system abstracts common design solutions from various disciplines into modular packaging algorithms to achieve automated design, and uses mature experience values as system default values for reference, to maximize design efficiency and reduce design bias caused by differences in experience and capabilities of participating engineers [14].

As shown in the figure above, the overall process has 1-9 and nine steps:

1. According to the wind speed, 10 kinds of fans are to be arranged; if multiple models are needed, the impeller diameter of the wind turbine shall be sorted from large to small;
2. The boundary according to the boundary distance and the restricted area;
3. Automatic estimate of capacity, determine the number of cloth machines of each machine;
4. According to the surface features to decide the distance from the city.

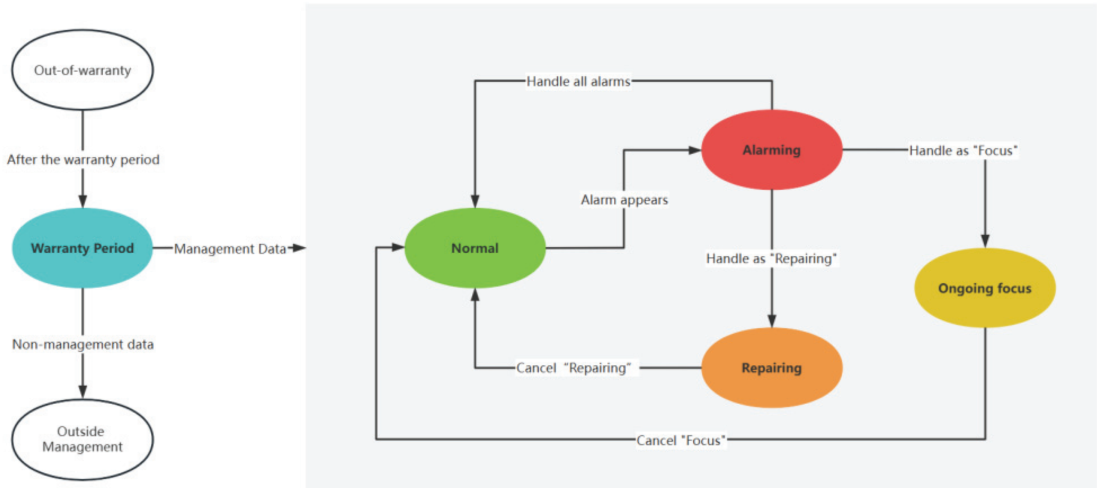

Figure 2: Data monitoring alarm and exception handling process.

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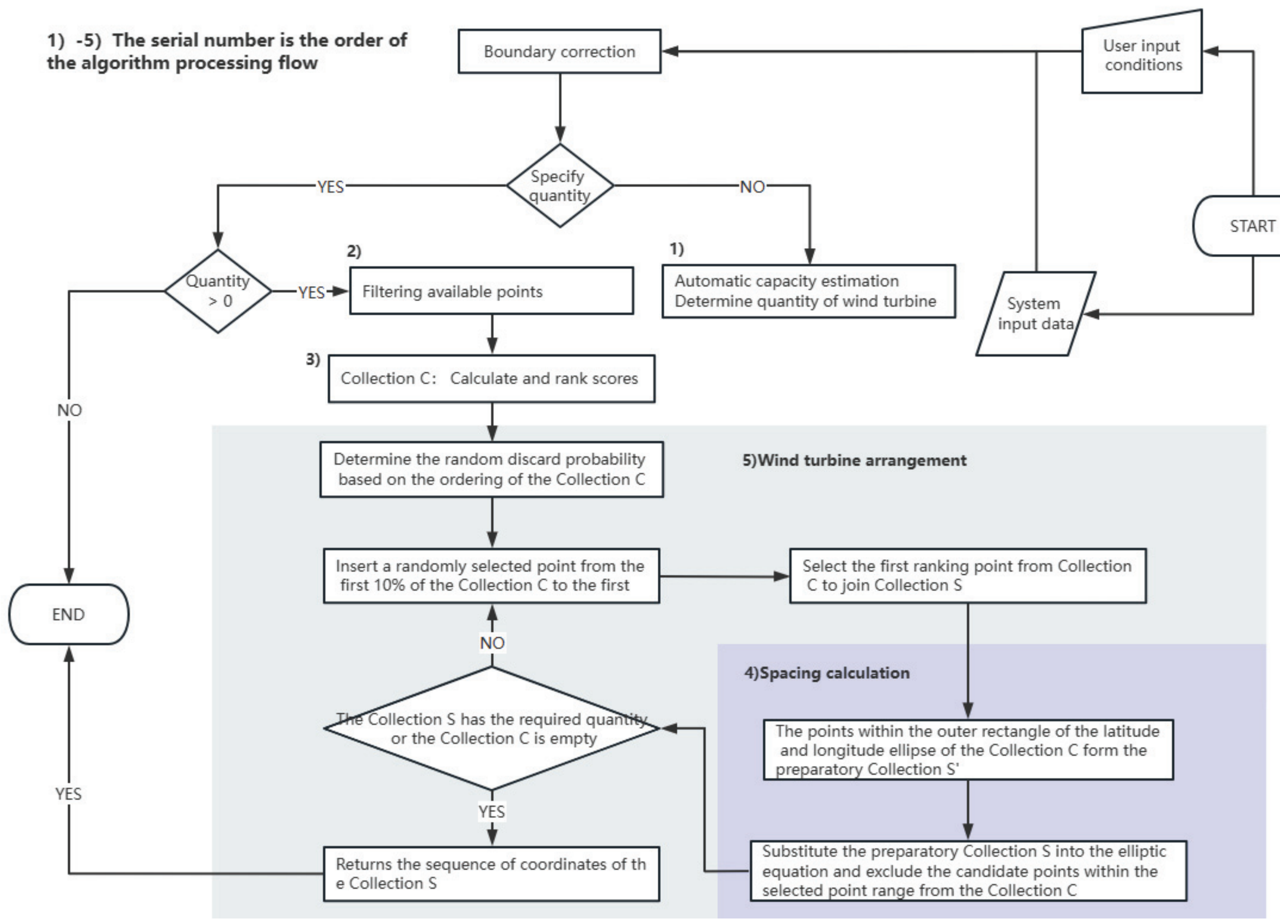

Figure 3: General flow diagram of the automatic position scheduling steps

5. Select the available machine points according to the identification, average wind speed, distance from the city, slope, altitude, etc. within the boundary; When the average wind speed and other wind resource data within the boundary do not exist, the average wind speed weight is not considered;
6. Calculate the equivalent hours according to the A, k value and the unit power curve of the wind turbine to be arranged;
7. According to the altitude, slope, curvature, equivalent hours, and each weight configuration, calculate the comprehensive score of each available cloth machine point;
8. Then, the comprehensive score of the available machine points is sorted to form an orderly candidate set C and determine the discard probability according to the ranking order, and randomly discard a small number of candidate points;
9. Determine the distance between the selected wind turbine, select the machine points that meet the spacing requirements, and form the selected point set S, if there is a fixed machine site parameter, the fixed machine site is directly added to the selected point set;

Scoring evaluation system

The data range of the four indexes is quite different, so it is normalized first, and then weighted to obtain the comprehensive score.

1) Altitude

$$Normalization\ Altitude = \frac{Altitude - Min.Altitude}{Max.Altitude - Min.Altitude}$$

Min. altitude = max (wind farm altitude 5% quantile, Min. altitude threshold)

Max. altitude = min (wind farm altitude 95% quantile, Max. altitude threshold)

The actual value of the altitude in the high-precision DEM data ranges from -800 to 8848, so the actual threshold is set as follows:

Min. altitude threshold=0, Max. altitude threshold=9000, altitude less than 0 m is a negative score, The higher the Altitude, the higher the score.

2) Slope

$$Normalization\ Slope = \frac{Max.\ Slope\ threshold - Slope}{Max.\ Slope\ threshold}$$

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In the actual situation, it is not suitable for the construction of the fan when the slope is greater than 30 degrees: Max. slope threshold=30, The lower the Slope, the higher the score.

3) Curvature

Normalization curvature = sign(Curvature) * (Curvature-Min.curvature threshold) * Scaling factor

Curvature 95% quantile>Min. curvature threshold,

$$Scaling\ factor = \frac{1}{Curvature\,95\%\,quantile - Min.curvature\,threshold}$$

Curvature 5% quantile<-Min. curvature threshold,

$$Scaling\ factor = \frac{1}{-Min.curvature\,threshold - Curvature\,5\%\,quantile}$$

Min. curvature threshold=0.001, Curvature 95% quantile, Curvature 5% quantile, the above constants are due to practical experience. The higher the Curvature, the higher the score.

4) Equivalent hours

$$Normalization\ equivalent\ hours = \frac{Equivalent\ hours - Min.Equivalent\ hours}{Max.Equivalent\ hours - Min.Equivalent\ hours}$$

The higher the Equivalent hours, the higher the score.

The distance between turbines

The distance between the elliptical wind turbines is not allowed to be within the ellipse range of the other party. Setting the long half-axis and the short half-axis to the same value is equivalent to the circular area limit.

When the long axis rotates θ° clockwise (i. e., the main wind direction is not due north), to determine whether the point is in the oblique ellipse of the origin, according to the elliptical equation:

$$\frac{(x * cos\theta - y * sin\theta)^2}{b^2} + \frac{(x * sin\theta + y * cos\theta)^2}{a^2} < 1$$

To determine whether the point is within the range of the oblique ellipse around the central point(x', y'), the oblique ellipse should be translated. The ellipse equation is:

$$\frac{((x-x') * cos\theta - (y-y') * sin\theta)^2}{b^2} + \frac{((x-x') * sin\theta + (y-y') * cos\theta)^2}{a^2} = 1$$

The above is based on the Cartesian coordinate system, slightly modified for the latitude and longitude coordinate system to obtain the following formula:

$$D = 2 * a\sin\sqrt{sin^2\frac{lat2 - lat1}{2} + cos(lat2) * cos(lat2) * sin^2\frac{lon2 - lon1}{2}} * 6371 * 1000$$

Of these, 6,371 are the radius of the Earth, in km. Multiplied by 1000 Convert the units to m.

In addition to the above basic calculation, the dynamic interaction between two closely spaced vertical-axis wind turbines can be analyzed numerically by considering the aerodynamic forces acting on each turbine, the wake interaction between them, and the structural response of the turbines to these forces. Through this analysis, the optimal spacing and orientation of the turbines can be determined to minimize the negative effects of wake turbulence and maximize power generation efficiency [15].

AI to optimize turbine design and site layout

Computational Fluid Dynamics: Used to simulate the behavior of wind over and around turbines, taking into account the turbine blade design, site topography, and atmospheric conditions. This helps to optimize the turbine design and site layout, taking into account the wind speed and direction, turbulence intensity, and other environmental factors [16].

Reinforcement Learning: Used to optimize the control of wind turbines. For example, an RL agent can learn to adjust the pitch and yaw of the turbine blades to maximize energy output while minimizing damage and wear and tear. And also, be used to optimize the site layout by identifying the best position for each turbine based on real-time data on wind conditions and turbine performance [17].

Agile development

There are many common features in the design and implementation of wind and solar resource power generation projects. We combine them to achieve common software functional modules, such as resource data query methods, measured data processing methods, and basic algorithms for power station design. Develop these modules that are highly versatile and frequently used in the industry into self-developed platform systems and provide them to relevant parties as basic services. Simultaneously, due to there being frequently personalized requirements beyond common functions, such requirements frequently manifested in differences in the enterprise power station project management, business process implementation, and so on [18]. As a result, we use agile development techniques to address various needs and continuously enhance the platform's features.

Conclusion and prospect

The project development capability of the new energy power generation industry is maturing. Project development from the ability to gradually develops the pursuit of more standardized development methods, cost reduction, and efficiency of the development process. Using high-quality software product tools combined with engineers' design experience is more conducive to the modernization of the industry. In the long run, we should be committed to promoting the level of information and digitalization of new energy generation to a new level [19].

Promoting the informatization and digitization of new energy power generation should be a long-term goal. Supporting the industry's development and efficacy entails ongoing improvement and technological advancement. We will also contribute our own strengths to this advancement as the development of the industry and the development

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of information technology complement and promote one another. The advancement of industry and the advancement of information technology complement and promote each other, and we will contribute our own strengths to this advancement.

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