Optimization Design of Solar Power Generation System Based on Big Data

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Abstract. Based on the data analysis and collection of optical thermal power station, this paper uses big data and machine learning method to mine the knowledge and rules contained in various data to guide the operation. Combined with various data sources, the model is established, and the system optimization and operation reference research are carried out.

Key words: Solar thermal power generation, big data.

1. Introduction
Solar thermal power generation, also known as concentrating solar power (CSP), its basic principle is to use a large number of mirrors to gather the solar radiation energy on the heat absorbing device. The accumulated solar radiation energy is converted into heat energy on the heat absorption device and transferred to the heat transfer fluid. Finally, the heat energy of heat transfer fluid is converted into electrical energy through turbine machinery or other power generation equipment. Solar thermal power generation system can be divided into three parts: concentrating heat collecting system, heat storage and heat exchange system, and power island system, which respectively represent the collection, storage and conversion of energy. The amount of energy collection depends on the solar energy resources to a large extent. Because the energy input link may change constantly, we need to pay more attention to the overall scheduling and operation in the operation process. Therefore, in addition to the integration, design and implementation process of traditional industrial projects, the analysis of project data information, optimization of operation process and debugging are very important. Solar thermal power station involves monitoring nodes and operation scheduling data. Data collection, analysis and utilization are the key to success or failure. It is imperative to optimize and innovate the system by using industrial big data technology. At the present stage, big data companies generally do not understand the process flow of industrial sites. Traditional engineering participants have not kept up with the accumulation of big data technology, and the field of industrial big data based on field data is still in a blue ocean.

2. Weather Resource Forecast Based on Big Data Analysis Method
During the operation of photo thermal power station, the prediction of weather, especially cloud is a very important and difficult module. Cloud prediction of tower type photo thermal power station is firstly a time series prediction problem. Secondly, due to the characteristics of its input data,
corresponding preprocessing, feature extraction and pattern recognition are required. Generally speaking, the overall process can be divided into the following parts:

2.1. Detection and Tracking of Moving Target
Moving object detection and tracking is a complex problem. The related aspects include the number of data sources (the number of cameras), the form of sources (dynamic and static) and the characteristics (number of targets). According to the number of cameras used, it can be divided into single camera moving object detection and tracking and multi camera moving object detection and tracking. According to whether the camera is moving, the problem of image tracking can be divided into moving object tracking when the camera is still and moving object tracking when the camera is moving. The number of moving objects in the scene can be reduced to single moving target and multiple moving target. The characteristics of moving objects in the scene also include: rigid body or non-rigid body. According to the different types of moving objects in video scene, the problem of moving object detection and tracking can be divided into rigid tracking and non-rigid tracking. The so-called rigid body refers to the object with rigid structure and not easy to deform, while the non-rigid body refers to the object whose shape can be changed. A common method to track this kind of target is to use deformable template to track.

It can be seen that the cloud prediction problem can be attributed to the problems of multiple cameras, multiple moving targets and non-rigid targets. Although it has a high degree of difficulty, some achievements have been made in image processing, machine vision and other related fields. In this project, we apply the methods in related fields to cloud prediction, and make relevant improvements, so as to complete the goal Preliminary detection and tracking of the target.

2.2. Prediction of Time Series
In addition to the above dynamic target detection and tracking problem, the time series prediction problem for cloud prediction is not different from the ordinary time series problem. It mainly includes: data collection, feature selection, model building and so on. The corresponding data preprocessing, feature selection and selection can be carried out by general methods. In the model establishment, the project will use Markov chain, extreme learning machine, deep learning, support vector regression and other related attempts, and consider the use of hybrid model, as far as possible to predict cloud cover in advance, to buy time for the control system, to improve the overall efficiency of the sun island.

3. Optimization of Concentrating Mirror Field Based on Machine Learning Algorithm
For solar thermal power generation system, its efficiency and power generation are often restricted by the efficiency and heat collection of the concentrating heat system. In order to make the solar energy can gather on the heat absorption device as much as possible, it is necessary to adopt reasonable layout to ensure less shadow shading and improve the utilization rate of solar energy. Taking a 50MW tower solar thermal power station as an example, about 30000 heliostats are needed. If the scale is larger, the number of heliostats will be further increased. It needs a lot of calculation and simulation work under different solar angles to arrange the heliostat on limited land. As shown in Fig.1, the distribution of heliostat in the interval with different tower distances is shown.

![Figure 1](image)

**Figure 1.** The distribution of heliostat in the interval with different tower distances is shown
The layout objectives of concentrating mirror field include the highest optical performance and the lowest comprehensive investment of land and absorber, which is a typical multi-objective optimization problem. The independent variable of the system is the three-dimensional coordinate of the heliostat. If the global optimization is needed, the variable level should be more than 100000. It is difficult to obtain a better row by using the traditional engineering calculation method. As shown in Fig.2, Several typical arrangements of heliostat field.

![Figure 2. Several typical arrangements of heliostat field](image)

In this paper, we use the method of machine learning to carry out related attempts, and achieved certain results. The standard algorithm is used as the prior knowledge and initial value of the initial input. Aiming at the problem that the standard bionic mirror field uses fixed heliostat position adjustment coefficient, which leads to the decrease of the peripheral efficiency of the mirror field, the swarm algorithm is used as the iterative optimization based on the initial value, and the position adjustment coefficient of the heliostat is set as a variable according to the actual change; finally, through encapsulation iteration and optimization An efficient field layout method of tower type photothermal mirror is obtained. Finally, the heuristic algorithm and swarm intelligence algorithm are used to determine the bionic helix and the position adjustment coefficient of heliostat according to the specific situation, so as to reasonably arrange the mirror field. The comparison with other mainstream mirror field layout schemes also shows that the invention can arrange the maximum number of heliostat on the smallest land area, and reduce the shadow and occlusion loss, atmospheric attenuation loss, truncation loss, etc., so that the annual average optical efficiency of the mirror field is the highest and the land use area is the lowest.

4. System Scheduling Optimization Method Based on Data Analysis Method
Solar thermal power station system belongs to a more complex system, in which there are many running modules, so it is difficult to match the system. In the process of system optimization and scheduling, it is necessary to identify and analyze each module in the system, and finally realize the overall scheduling. Through the analysis of operation data, this project can better grasp the real operation of each link in the system, and finally complete the system optimization and scheduling strategy formulation to the greatest extent.

5. Prospect Analysis
At present, China is vigorously promoting the development of photothermal industry, among which the first batch of demonstration projects are being promoted, and the follow-up projects are also actively reserved. As a supporting optimization product in the development process of solar thermal power station, this project can shorten the commissioning period, improve the power generation efficiency and increase the power station income without increasing hardware investment. Taking a 50MW Single Tower Photo thermal power station as an example, combined with the simulation results, if the commissioning period is shortened by one year by using relevant technologies, the economic benefits will be more than 100 million yuan. If the solar, wind, cloud and other resources are predicted by using
relevant technologies, the efficiency can be improved by 0.5%. A single power station can bring more than one million economic benefits every year, with a twenty-five-year life cycle. Nearly 30 million. At present, the 13th five-year plan for solar energy development clearly points out that by the end of 2020, the installed capacity of solar thermal power generation in China should reach 5 million KW. During the 13th Five Year Plan period, the market scale of solar thermal power generation in China will reach at least 100 billion yuan. According to the different heat storage hours, the current annual utilization hours of photo thermal power stations are generally about 3000 to 4500 hours. In this way, at the end of the 13th five-year plan, the annual power generation of solar thermal power stations is nearly 20 billion kwh, which can increase the efficiency by 0.5%, and increase the power generation capacity by about 100 million kwh. The economic benefits brought by the current electricity price of 1.15 yuan are quite considerable.

6. Concluding Remarks
Energy is the basic support of national economy and the material basis for human survival. Solar thermal power generation, as one of the solar thermal utilization technologies, combined with large-scale heat storage technology, has the main characteristics of long-term continuous operation, stable and controllable power generation, flexible operation mode, etc., so it has great development potential. Solar thermal has the characteristics of stable and controllable power generation, flexible operation mode, combined heat and power supply, peak load regulation for other new energy sources. It is expected to undertake the system base load in the future, which can meet the current requirements of energy conservation and emission reduction, clean energy utilization and haze control in China, and has a broad market prospect.

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Yuwen Liang, (1982-), Associate professor, Postgraduates, North China Electric Power University. Get prizes many times in guiding students to participate in national and provincial skills competitions for many times, and get the first prizes in national teacher’s skills competition for twice. be as awarded the title of "national practice expert".

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