A Display Method for Large-Scale Transmission and Transformation Equipment Load Capacity Spatio-temporal Data

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Abstract. With the rapid growth of the power grid scale, the higher requirements are put forward for power grid safety and power supply reliability. In order to display power transmission and transformation equipment state information better, this paper puts forward a method to display large-scale transmission and transformation equipment load capacity spatio-temporal data. The data of different systems are integrated and processed, and the load capacity of the power grid equipment is finally obtained. The distribution of equipment load capacity is realized by drawing the transmission equipment on the map with its load capacity information. Finally, combining time and space information, we realized the dynamic rotation of load capacity of power grid transmission and transformation equipment. Through dynamic playback, it can show the inherent laws of equipment load capacity’s change and effectively solve the defects of the present display method. Finally, it provides the basis for the maintenance personnel to carry out equipment maintenance.

1. Introduction

Power transmission and transformation equipment is the basis unit of the power grid operation. Comprehensive and accurate evaluation, diagnosis and prediction of equipment status is the premise of state overhaul and life-cycle management of transmission and transformation equipment. Also it provide important basis for intelligent dispatching operation. It can provide strong technical support for the safe, reliable and efficient operation of the power grid. The load capacity assessment of transmission and transformation equipment can effectively improve the current carrying capacity and utilization efficiency of existing equipment under the premise of safety\cite{1-3}.

In recent years, with the improvement of intelligent power grid and the level of information technology, we have accumulated large-scale spatio-temporal data of power transmission and transformation equipment load capacity\cite{4}. But we still lack effective visualization to show it. Previous display of transmission and transformation equipment load capacity is from a single dimension (e.g., time dimension), usually using a line chart, etc. It is difficult to visualize the load of power transmission and transformation equipment for the equipment operation and maintenance personnel.

Therefore, study on load evaluation of transmission and substation equipment in panoramic information state become particularly important. Also establishing a visualization model of
transmission and transformation equipment load capacity based on spatio-temporal fusion has a great significance for load capacity enhancement[5,6].

In this paper, we present a visual display method for spatial and temporal data of power transmission and transformation equipment load capacity based on GIS map[7], which mainly includes the following three aspects:

- Realized the display of transmission and transformation equipment on the map through the topological structure of transmission and substation and circuit.
- Realized dynamic display of different equipment load capacity through different levels of load capacity.
- Realized dynamic rotation through the load capacity data of different time sections.

2. Visual preparation

2.1. Data preparation

Currently, the multi-level and multi-dimensional data of transmission and transformation equipment state, power grid information and environmental information provide data bases for the display of load capacity of power transmission and transformation equipment. In order to visualize the dynamic load capacity of transmission and transformation equipment, we mainly adopted data from power production management system(PMS), energy management system(EMS) and geographic information system.

The data in PMS is mainly standing book of power transmission and transformation equipment, mainly including equipment nameplate, technical parameters, equipment management information, etc.

The data in EMS includes network normal and accident trend information, power grid fault and tripping information, network topology information, etc.

The data in GIS includes geographic location information of power transmission and transformation equipment.

The use of the three systems can be viewed through the Table 1.

| Data source | Use |
|-------------|-----|
| PMS         | The matching of EMS data of the same type Providing data support for the calculation of equipment load capacity; Realizing the corresponding of geographical location and GIS coordinates. |
| EMS         | Providing support to the display on the map for transmission and transmission equipment. |
| GIS         | |

2.2. Data processing

The data of the above three systems is characterized by multiple sources, heterogeneous information, and it is difficult to guarantee data integrity, validity and consistency. To ensure the validity of the data, consistency and integrity, we need to conduct a preliminary data cleaning through statistics and clustering, time series analysis technology such as smoothing noise, missing value filling, identify outliers, etc.

Then we need to calculate the load capacity of the transmission and transformation equipment. Transmission line load evaluation as object of study, has been associated with overhead transmission lines (cable) load capacity of the parameters of overhead transmission lines (cable) load capacity influence parameters (temperature, wind speed, wind direction, load and the sag, conductor
temperature); Download build steady flow calculation model - climate model (WM), download the steady-state flow calculation model - conductor temperature model (CTM), transient load flow calculation model[8]; On the basis of the introduction of Shandong province meteorological statistical analysis of historical data and the boundary conditions of the analysis results of data mining, build the meteorological, load, analysis of transmission equipment state information fusion multiple time scale dynamic load capability assessment and prediction model; Transformer as the object of study, through the analysis of transformer internal heat process, according to the transformer operating environment temperature, and the special position of transformer oil temperature, the real-time load data calculation of winding hot spot temperature on the Shandong power grid based on the analysis of the huge amounts of data, is presented based on the "hot spot temperature correction factor" equipment dynamic capability evaluation model of each failure mode by collecting samples, temperature and load are calculated under various fault "hot temperature correction factor value," the dynamic transformer capability assessment[9]. This paper uses statistical analysis, correlation, regression analysis and machine learning to implement evaluation of equipment load capacity[10]. The implementation is shown in the figure 1.

![Diagram](null)

**Figure 1.** Load capacity calculation process.

Through the above methods, we obtained the load capacity of different equipment, and we need to determine the location of the equipment.

We need to coordinate transformation of geographic data, including transformation of geographic coordinate system and coordinate format. In general, the association coordinates of the original data are collected by GPS devices. The coordinate system used is WGS-84, and the coordinate format is generally in degree/minute/second format (DMS). Based on the power map to realize the visualization of load capacity of power transmission and transformation equipment, the power map uses its own coordinate system, BD-09, and the coordinate format is the decimal angle (DD). This paper uses the coordinate transformation interface provided by power map to realize coordinate transformation from WGS-84 to BD-09. Degrees/minutes/seconds format (DMS) coordinates can be expressed as "dd mm ss". The form of a decimal point (dd) coordinates can be expressed as "dd.ff". Conversion from degree/sub/second format (DMS) to decimal point (DD) can be used in equation (1) representation.

\[
dd_{ff} = dd + mm / 60 + ss / 3600
\]  

(1)

Summarizing the visual preparation mainly includes the following aspects:
- Data accessing and cleaning of three systems.
- Calculation of load capacity of transmission and transformation equipment.
- Realized dynamic rotation through the load capacity data of different time sections.
• Correspondence between transmission and transformation equipment and GIS geographic coordinates.

3. Visual display
Through the above data preparation process, we have accumulated a large amount of spatio-temporal data, which includes a huge amount of point data and line data and load capacity data. The visualization method that presented in this paper is mainly divided into three steps.

3.1. Mapping
We can abstract the substation and line of the equipment into point data and line data. When we make a map, the visualization of point data and line data has its own characteristics.

3.1.1. Visualization of mass point data
When we draw transmission and transformation equipment on a map, there is a lot of overlap between points. That is because a large number of devices are located in the same substation. To solve this problem, we only draw substations. At the same time, when the data distribution is not uniform, there will be a large number of points overlapped in the dense data areas, while the sparse data will be mostly empty. To solve this kind of problem, there are two ways:

- Divide the map into blocks and display the most representative data.
- Use dye and fusion to fully represent each data object.

3.1.2. Visualization of mass line data
In the face of transmission line data, the main problem of visualization is how to reduce overlap and crossover. If the purpose of data visualization is to understand the overall pattern, rather than show each line segment. We can adopt an appropriate simplification method to cluster a large number of lines and visually display the patterns inherent in the data. In addition, in order to alleviate the demand for the calculation ability of mass line data, the line data can be properly abstracted and aggregated.

Finally, through mapping the Shandong power grid transmission and transformation equipment, we obtained figure 2. We can clearly see the distribution of Shandong power grid transmission and transformation equipment, and we also draw the weather warning information on the map. Therefore, we have a comprehensive understanding of shandong power grid.

![Figure 2. Mapping transmission and transformation equipment](image)

3.2. Displaying different levels of load capability.
In order to reflect the state of the equipment better, we graded the load capacity. The specific classification is shown in table 2. The load capacity classification can help the operation and maintenance personnel to understand the state of the equipment and make the maintenance plan. We divided the load capacity into four levels, including strong, more strong, less weak and weak. The weak and less weak are the state that the operation and maintenance personnel need to pay attention to the stress.

| Level      | status  |
|------------|---------|
| Strong     | normal  |
| More strong| Abnormal |
| Less weak  | attention|
| Weak       | Serious  |

After grading the load capability data, we map it to the map. We can see from figure 3, different colors represent different levels of load capacity. The red is weak. The orange is less weak. The yellow is stronger. The green is strong.

3.3. Dynamic rotation of load capability Spatio-temporal Data

Each load capacity data is marked with two attributes: latitude and longitude; The time attribute indicates the time point of load capacity as the timestamp. Through the combination of time and space, the distribution of power transmission and transformation equipment load capacity can be comprehensively studied, which can make the visual display of load capacity more comprehensive and more effective. Because a large number of devices are located in the same substation, we show the equipment in the most serious condition. At the same time, we calculated the load capacity of all the equipment on minute level and hour level. In figure 4, it shows the change of the Shandong power grid load capacity for twelve consecutive hours. Finally, we realized the dynamic rotation of the load capacity of the transmission and transformation equipment.
4. Conclusion
This paper discussed the grid power transmission and transformation equipment load capacity spatio-temporal data’s visualization display method. We realize the display of the load capacity in time and space dimensions. It can help the operation and maintenance personnel to repair the equipment. Through the display of time and space integration, the distribution of load capacity can be revealed, and the distribution of load capacity does show different characteristics of different devices in time and space dimensions. The display method for large-scale transmission and transformation equipment load capacity spatio-temporal data changed the previous traditional display form. It can help power grid to solve the peak load or part of the equipment failure (or maintenance).

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