Design of intelligent distribution network based on Geographic Information Technology

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Abstract. According to the business requirements of distribution network planning, this paper deeply studies the existing simplified display algorithm of distribution network in GIS, constructs the distribution network model based on geographic information technology, develops the functions of supporting storage, display and display, and the function module of professional map editing for distribution network planning. The concept of spatiotemporal data and its application in GIS are innovatively put forward. The display research based on the status quo and the analysis and management technology of distribution network structure under planning state are carried out. The spatiotemporal representation, spatiotemporal evolution, and comparison of power grid are realized. The geographic image elements are matched and associated with equipment parameters to realize the integrated modeling of map and power grid, realize the penetration function from the map to equipment parameters and power grid indicators, and support the diagnosis and analysis of power grid-related indicators. Finally, a three-dimensional power map with time dimension, space dimension, and attribute dimension is constructed to provide geographic environment and equipment parameter data for power grid planning, site selection, and line selection.

1. Introduction

At present, geographic information technology has been widely used in transportation inspection [1], marketing [2], communication [3], UAV [4], and other business departments, but it has not yet formed a unified application in the development of professional, and due to the different focus of attention, the grid model and related graphical research results designed in the different business fields are not fully applicable to the development of professional fields. Therefore, it is necessary to design the relevant power grid model for business development [5], form the grid diagram of the development specialty [6], study the graphical analysis [7], and display application of the development specialty [8] based on the grid diagram.

In this paper, because of the demand for the construction of the three-dimensional integrated power map of the distribution network, the geographic information technology is introduced, the application
of the distribution network structure diagram and related graphics for the planning specialty is formed, and the application research of the related function of the planning based on the map is supported, as shown in Figure 1. The main work includes: 1) automatically collect the archives, operation and topology data of the company, and collect the power grid resource data meeting the professional development needs; 2) integrate the geographic information resources and power grid information resources, combine the GIS current grid structure diagram with the relevant data of the distribution network data analysis platform, and carry out the map data, grid data, file data and operation data Integrated integration, the establishment of time, space, attribute three-dimensional integrated power map, forming a distribution network structure map for planning professional; 3) through the use of GIS mapping services, topology services and data services, the grid structure is presented on the map, showing all kinds of equipment concerned in the planning; accurate grid topology information is provided to support based on grid topology 4) realize the associated query of grid equipment graph, file, operation and other data, simplify the access to grid data matching, and provide data support for planning status analysis, load forecasting and other applications.

![Three-dimensional integrated power map](image)

**Figure 1. Three-dimensional integrated power map.**

2. The overall design of the electric power map

The smart grid transmission line condition monitoring center includes many special application systems that meet different business requirements. Each special application system has its system architecture and corresponding projects to promote the operation. The GIS platform of transmission line operation condition monitoring must be comprehensively analyzed and designed under the existing system framework system, and the existing system construction should be fully utilized At the same time, it provides GIS support for special application systems.

The platform data layer includes GIS data and thematic attribute data. GIS data mainly includes two parts: one is a background map for geographical reference, including a two-dimensional vector electronic map and three-dimensional terrain scene map; the other is thematic spatial data, including vector feature layer and thematic three-dimensional model. The two-dimensional electronic map is mainly based on the digital topographic map, which provides the thematic representation under the orthophoto plane perspective. The three-dimensional terrain scene map is mainly based on DEM, image, and vector data to provide the thematic performance under the three-dimensional panoramic perspective. The thematic attribute data mainly includes the account information and real-time monitoring information of transmission lines and monitoring equipment, which belongs to the special data of the power sector. These data are provided by the power department and have formed a relatively complete management and use mechanism. In the construction of this platform, there is no
need to process and manage, nor do any data storage, and are obtained through real-time call. And carry out related applications.

The method of data fusion is shown in Figure 1. Based on PMS system equipment files and graphic data of the equipment department, EMS and DMS equipment operation data of dispatching center, and user files and operation data of the marketing business application system and power consumption acquisition system of the marketing department, grid graphic resource data is applied to match and fuse the collected business data information through equipment ID, name and other data items. To get through the data interaction channel between business systems, and provide strong data support for the development of professional business applications at all levels.

3. Grid structure model for planning specialty
The main functions include storing, displaying, and editing the grid connection diagram and electrical topology diagram, and supporting the display and analysis of the relevant indicators of the power grid. At the same time, the grid simplification algorithm is improved to generate a geographical wiring diagram which is closer to the actual power grid trend, shows the T-connection status of lines, and distinguishes the overhead and cable characteristics. According to the type of power grid equipment and voltage level, the power grid path and grid structure are displayed. Intuitively understand the power grid path and grid structure within the scope of business. The steps are as follows:

1. Substation outgoing line arrangement: Based on the sequence of substation outgoing line interval in the current power grid as a reference, to reduce the occurrence of cross and overlap in the substation, rearrange the substation interval and stagger the multi-circuit outgoing cable of the substation.

2. Line Simplification: the line simplification mainly includes two aspects: the external contour simplification of the line and the deletion of the secondary equipment of the line. The idea of the external contour simplification is to abstract the selected trunk line as a multi-segment broken line data model and set the reduction rules of the relevant associated attributes (such as for a single segment on both sides of the line) based on the attribute correlation of the length of the single segment broken line, the angle between the broken line and the overall line extension direction. The broken line length is less than 10 meters, and the break angle is greater than 135 degrees. The broken lines at both ends are merged to remove the break angle and straighten the line; the specific rules are to be verified by continuous tests), and the line is simplified iteratively. The deletion of line secondary equipment refers to the deletion of auxiliary equipment and secondary equipment such as straight pole, lightning arrester, Pt, etc. in the line, and the equipment concerned with the planning drawing shall be retained.

3. Line shifting: line shifting refers to adjusting the position of lines in the same geographical location to make them offset the actual position appropriately, reduce the cover and improve the readability of the map. Through the shift operation, the problem of mutual covering between the line objects represented by symbols is solved, and the similarity between the map content and the field is ensured. The idea of line shifting is to abstract all line model data in the grid cell, set the critical value of line capping, realize the determination of line capping between multiple lines with the help of GIS spatial analysis service, and then conduct the overall offset operation for the capped lines.

4. Spatio-temporal data
Based on the business characteristics of power grid development, the concept of multi-temporal is introduced into the analysis of distribution network structure, and the concept and application of spatiotemporal data are innovatively proposed with the combination of geographic information technology. The research on the display, analysis, and management technology of distribution network structure based on current state and planning state is carried out to make the network structure present spatiotemporal, and realize the spatial-temporal evolution and comparison of grid structure.

4.1. Historical power flow analysis of power grid
The historical power flow information is the most intuitive embodiment of the overall power grid operation. In this paper, through the collection of dispatching operation data, the integration of grid
data, the application of geographic information technology, combined with the planning business needs, the historical power flow information of the power grid can be visually displayed on the map. By accessing the dispatching operation data, matching the operation information at both ends of the line, the power flow diagram is generated, which can truly restore the power flow direction at historical times, and provide reference for the feasibility, reliability, and economy of power supply planning. Combined with the planning business requirements, the historical power flow information of the power grid can be displayed intuitively on the map.

4.2. Two source unified information model

Through the dual space of geographical resources and power grid resources, the integrated modeling of map and network is carried out. Combined with the multi-temporal distribution network structure display, the power map with time dimension, space dimension, and attribute dimension is constructed. The grid is displayed and analyzed based on geographic information, and the penetration function from the map to equipment parameters and power grid indicators is realized through the matching of distribution network equipment ID, and the geographic image elements are associated with the equipment parameters matching. At the same time, the grid-related indicators such as medium and low voltage power supply radius, line installation and distribution transformer capacity, line basic information account, and negative voltage can be analyzed according to geographic information support. It can provide geographic environment data support for planning site selection and route selection.

5. Test

Based on the analysis of the current grid structure, the geographical connection diagram of the transmission network is automatically simplified and manually optimized to meet the needs of planning specialty. Based on the simplified results of the current grid structure of the headquarters transmission network, the simplified algorithm of the grid structure is further iterated. The drawings are more close to the actual power grid trend, and can accurately show the line t-contact, and distinguish the characteristics of overhead and cable, as shown in Figure 2.

![Figure 2. Analysis of feeder trunk line.](image-url)
6. Conclusion
In this paper, using geographic information technology, innovative integration of power grid equipment resources and geographic information resources, in-depth study of the gridline simplification model in GIS, retain the information of power grid structure and line direction, reduce the complexity and simplification degree, build a grid geographic information map suitable for the characteristics of power grid planning, and realize the multi-angle display of power grid structure and sub-requirements. The concept of spatiotemporal data and its application in GIS are innovatively proposed. The spatiotemporal representation, spatiotemporal evolution, and comparative analysis of the grid are realized. The boundary between the map layer and the equipment layer is broken through. The geographic resources and equipment resources of source data are associated and matched. The integrated modeling of map and network is realized, and the penetration function of geographic information to equipment parameters is realized. Finally, a three-dimensional power map with spatial dimension, time dimension, and attribute dimension are constructed, which lays the necessary map number foundation for the follow-up research.

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