Design of 3D Model Database of Substation Equipment Based on Access Software

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Abstract. Building model base and sharing model effectively can accelerate the process of 3D new design and scene reconstruction, and reduce the cost of modeling has important engineering value. Based on the analysis of the functional requirements and architecture design of the three-dimensional model database of substation, this paper puts forward the storage information attributes and coding rules of the three-dimensional model database of substation typical equipment, and creates the three-dimensional model database of substation equipment based on access. The three-dimensional model database of substation includes model management and maintenance module, human-computer interaction module, which realizes the storage, storage, query and other functions of three-dimensional model of substation. The research results can provide reference for the construction of three-dimensional model base of substation equipment.

Keywords: substation, 3D model, database, access software.

1. Introduction

As the main part of the power system, it is of great significance to fully understand the basic structure and the actual distribution of power equipment for the daily maintenance of the substation and the reliable operation of the whole power system [1-3].Through the 3D reconstruction of the substation equipment and the use of 3D design results, it can realize the analysis and management of the substation equipment, and provide technical support for the 3D visualization of the substation [4-5].Therefore, a suitable tool is needed to manage and maintain the 3D design results of the substation.

In recent years, 3D model database technology has been gradually developed, 3D model database has been widely used in education, medical, military, power system and many other fields [6-11].In order to construct the three-dimensional visualization information platform of power grid, to realize the visualization of control center, operation and maintenance, and marketing management, many experts and scholars have begun to study the technology of three-dimensional data collection, 3D model construction of power equipment, and achieved some research results. However, with the development of power grid, the number of substations in operation is increasing gradually, the types and quantity of

3D models of equipment are increasing, and the quality is uneven. The lack of appropriate 3D model management tools challenges the reliability and availability of these models, mainly reflected in:

i) the accuracy and integrity of 3D model documents of equipment, the management habits of document managers are different and wrong Operation, personnel transfer, document change, loss and so on will make the accuracy and integrity of 3D model documents of equipment have problems, and the 3D model and equipment document information are independent of each other and cannot be directly related, which brings inconvenience to model management and application [12];

ii) 3D design and reconstruction of substation, research and application of 3D design and reconstruction of Substation. A large number of three-dimensional models have been produced. In this process, it is not difficult to find that different scale substations, or even different voltage level substations, will have the same manufacturer, the same model, appearance and function of the same equipment. Repeated modeling of the same equipment not only wastes a lot of manpower and material resources, but also seriously affects the efficiency of three-dimensional model reconstruction of substation. At the same time, different modeling manufacturers have different model granularity, data format and so on, which brings inconvenience to the later development and application of three-dimensional model. Therefore, it is necessary to build a three-dimensional model library of substation equipment and facilities, which contains a large number of qualified models, to realize the unified call, unified specification and unified management of the model, to realize the convenient and orderly management of the substation equipment model, and to greatly promote the process of model sharing, model reconstruction and three-dimensional design [13,14].

In view of this, this paper analyzes the functional requirements and architecture design of the three-dimensional model database of substation equipment, unifies the information needed for model warehousing, and builds the data management and maintenance module and human-computer interaction module of substation equipment based on access to realize the creation of the three-dimensional model database of substation equipment.

2. Functional requirements and architecture design of substation 3D model database

2.1. Functional requirements analysis of model base
The substation 3D model database shall have the following functions.

i) Management and maintenance of 3D model data and related information. With the development of power grid, the data of substation 3D model database is constantly modified and updated. Therefore, a data update platform with simple operation and easy to learn should be reserved to facilitate the management and maintenance of database managers;

ii) Review of 3D model. There are two ways to look up the 3D model data: one is aimless traversal, so the database needs to include all 3D models to facilitate the user to select appropriate objects; the other is targeted keyword query, so the database needs to have keyword query function, so that the user can quickly access the target objects from the massive data. In this process, it is necessary to unify the naming rules of the equipment model to avoid the situation of wrong selection, missing selection and no object due to the inconsistency between the key words and the model name. At the same time, it is also necessary to provide a multi key word search method to solve the problem that users cannot quickly select in the absence of information;

iii) Display function of 3D model. Only the name of 3D model and its related information can not show the specific structure of 3D model directly for users, which is not convenient for users to select and call the required model correctly. Therefore, it is necessary to have a simple, fast and vivid three-dimensional model display function to clearly reflect the overall structure of the model. At the same time, it is necessary to avoid the problem of slow viewing of the model due to the large volume of equipment model files and too many types of models.

2.2. Model library framework

In order to achieve the above functions, the database includes two modules: one is the model management and maintenance module, which is used for the management and maintenance of data in the database, mainly including three-dimensional model and related information addition, deletion, modification, update and other operations, while providing the underlying data source for the human-computer interaction module; the other is the human-computer module, whose main function is to create the human-computer interaction platform with users can realize 3D model traversal, query and display. Therefore, the module can be divided into three sub modules: traversal, query and display. Among them, the traversal module is realized by a clear tree structure, and the display module can display the selected object in real time. The overall database architecture is shown in Figure 1.
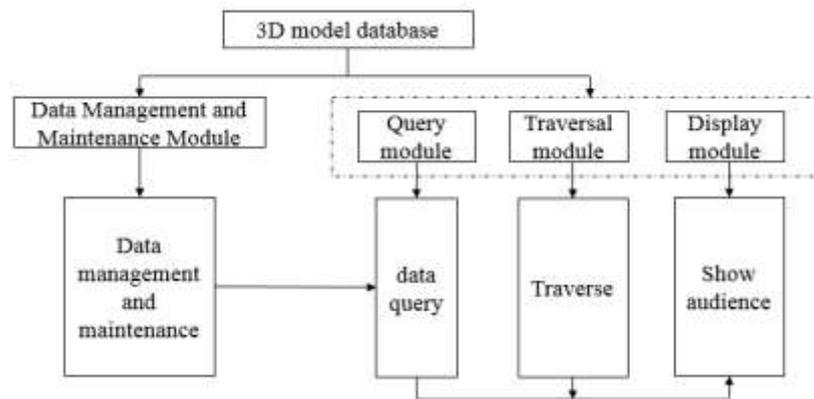
Figure 1. Database architecture.

3. Model receipt information attributes and coding rules

In order to use the three-dimensional model correctly and reasonably, the three-dimensional model and its related information should be unified when entering the warehouse, that is, to specify the type of information needed and the format of information entering the warehouse. Storage information shall include: equipment name, voltage level, manufacturer, equipment model, etc. This paper unifies these information as follows.

i) Name of equipment itself: Chinese name shall be used uniformly instead of English or Pinyin abbreviation or abbreviation, so as to avoid wrong selection or missing selection of query results due to different personal habits when querying by equipment name. If the model is a certain equipment part, the name shall include the equipment, such as "main transformer oil conservator", indicating the ownership of the part;

ii) Voltage level: the format of "Arabic numeral + voltage unit" is used uniformly. The voltage unit is not case sensitive, such as "500kV". There are many equipment with the same name and different voltage level in the substation. These equipment models should be distinguished by adding voltage level when entering the warehouse to avoid confusion;

iii) Manufacturer: the name of the manufacturer shall be consistent with the official name of the manufacturer, and cannot be abbreviated, so as to avoid wrong selection, missing selection and no result in the query results according to the manufacturer;

iv) Equipment model: the equipment model shall be consistent with the information on the corresponding parameter nameplate of the equipment, so as to ensure the accuracy of the equipment model parameters and provide the most accurate discrimination conditions for model selection. If the model is a certain equipment part and there is no corresponding equipment nameplate, the model number of the equipment shall prevail.

In order to facilitate the query, this paper proposes a way to query the equipment by means of equipment coding, that is, to add a unique code to each kind of equipment, code in the order of "voltage level + (equipment to which the component belongs) + (equipment type information) + Chinese name of equipment/component + (phase/sequence number)", the content of brackets is unnecessary information, which is added as needed, mainly as a supplement distinguish conditions. The content without brackets is necessary information. Equipment coding rules are shown in Table 1.

Table 1. Equipment code.

Voltage grade	Code	Device name	Code	Part name	Code
6kV	0006	Transformer	0001	High pressure bushing	0001
10kV	0010	GIS	0002	Respirator	0002
35kV	0035	Switching device	0003	Thermometer	0003
66kV	0066	reactor	0004	Relay	0004
110kV	0110	Capacitor	0005	Oil level gauge	0005
220kV	0220	Voltage transformer	0006	Oil pillow	0006
500kV	0500	Current transformer	0007	Cooling fan	0007
1000kV	1000	Lightning arrester	0008	corrugated pipe	0008
•••	•••	•••	•••	•••	•••

The equipment with the same voltage level and name shall be distinguished according to the equipment type information. In this paper, taking transformer as an example, the purpose, type, cooling mode, etc. shall be declared when coding the transformer, and the equipment shall be named according to the order of type + cooling mode + purpose. The coding rules of equipment type are shown in Table 2 below. For example, the equipment type code of single-phase auto coupling oil immersed onan / ONAF main transformer (cooling mode code selects the cooling mode at full load) is 1321 according to table 2.

Table 2. Equipment type code.

type				Cooling mode	Code	purpose	Code
Phase number	**Code**	**Winding form**	**Code**				
Single-phase	1	Double winding	1	ONAN	1	Main transformer	1
Three-phase	2	Three winding	2	ONAF	2	Station change	2
		Self coupling	3	OFAF	3	Grounding transformer	3
				OFWF	4		
				ODAF	5		
				ODWF	6		
•••	•••	•••	•••	•••	•••	•••	•••

Figure 2. Equipment coding rules.

4. Design of 3D model database of substation based on access

Access is the most popular desktop database management system based on Windows system in the world. It is an object-oriented development tool. It takes an application system as an object and simplifies the development work. It has the advantages of simple learning, friendly interface and simple operation [15].Compared with other kinds of database software, access does not need database management staff to have strong programming ability, which reduces the requirements of management staff.In this paper, access is used to create the three-dimensional model database of substation, which consists of the following two modules.

4.1. Data management and maintenance module

Data table is the source of access database data and the foundation of building the whole database system.The operations of adding, deleting, updating and maintaining data in access can be realized by modifying the data table.

Because the database traversal module in this paper is a tree structure, we should first clarify the parent-child relationship in the data table. There are many kinds of electrical equipment models in the 3D model database. For example, the transformer is regarded as a parent node. The respirator, radiator, conservator, etc. are all components of the transformer, which can be regarded as a child node of the transformer node. Meanwhile, the transformer and other equipment are also child nodes of the electrical equipment, as shown in Figure 3.Before the data table construction, the models in the database should be classified and sorted out, and the parent-child nodes between each model should be sorted out.
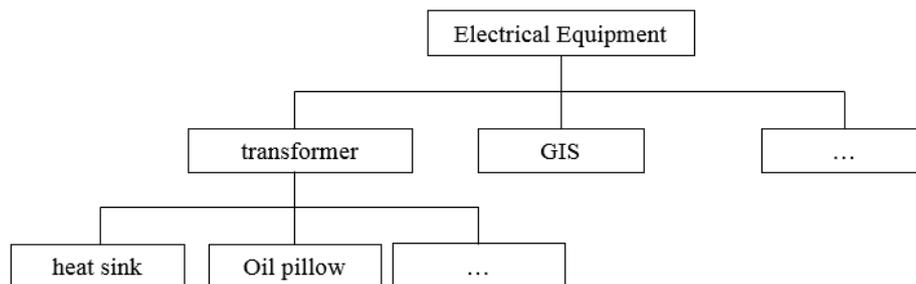

Figure 3. Node tree.

The data table of this paper includes: node information, model link, model name, model thumbnail, manufacturer, voltage level and other information.In addition, in order to create the tree view structure later, the node levels of each equipment are added, and the parent-child node relationship is combed. For example, the transformer belongs to the electrical equipment, which itself contains various components such as bushing, conservator, heat sink, etc., so the parent-child node relationship is shown in Table 3.

Table 3. Data table and parent-child node relationship.

Parent node	Child node	link	Model name	thumbnail	Manufactor	⋯
	1	-	Electrical equipment	-	-	⋯
1	2	-	Transformer	-	-	⋯
1	3	-	Transformer bushing	-	-	⋯
1	4	-	Transformer conservator	-	-	⋯
⋯	⋯	-	⋯	-	-	⋯

4.2. Human computer interaction module

This module is the core of the database design, which determines the display effect of the final database. Form in access is an interactive platform between computer and user. It does not have any content in database, and its data comes from data table.

4.2.1. 3D model display module. This module is used to display the model. No matter how the query module and traversal module are implemented, they need to have 3D display module to display the selected objects in real time. In this paper, the three-dimensional model of the database is displayed in the form of thumbnails, including two full-color views from different angles, one model split into thumbnails of main components, so as to quickly consult the three-dimensional design model in the substation, and new employees can quickly understand the main structure and function of each equipment, avoiding the time waste caused by the slow opening of the three-dimensional model and improving. For the actual model file, the file location is indicated in the form of hyperlink, taking the main transformer as an example, as shown in Figure 4.

(a)   (b)

Figure 4. Main transformer thumbnail. (a) Panoramic view of main transformer; (b) Main components of main transformer.

In this paper, the way to realize the 3D model display module is to use binding control, which is linked to the model and thumbnail in the data table by setting the properties of the added binding control, so as to realize the model display, which has the advantages of simple operation and easy maintenance.

4.2.2. Query module. The creation of the form and the realization of its functions are mainly realized through the event programming of various controls and corresponding controls. Event is a special operation performed in the database, which can be identified and detected by an object. When this action occurs on an object, its corresponding event will be triggered, such as mouse click, double-click, before update, after update, etc. The main function of this form is to query. The event is set to "= setfilter (text box name)", and the basic function of the query form is realized by programming the query form.The designed database provides three keyword searches, including equipment name, voltage level and manufacturer, and provides users with a variety of screening strategies, as shown in Figure 5 (a).Personalized settings such as the structure layout of the form can vary from person to person. The structure layout of the query form in this paper is shown in Figure 5 (b).
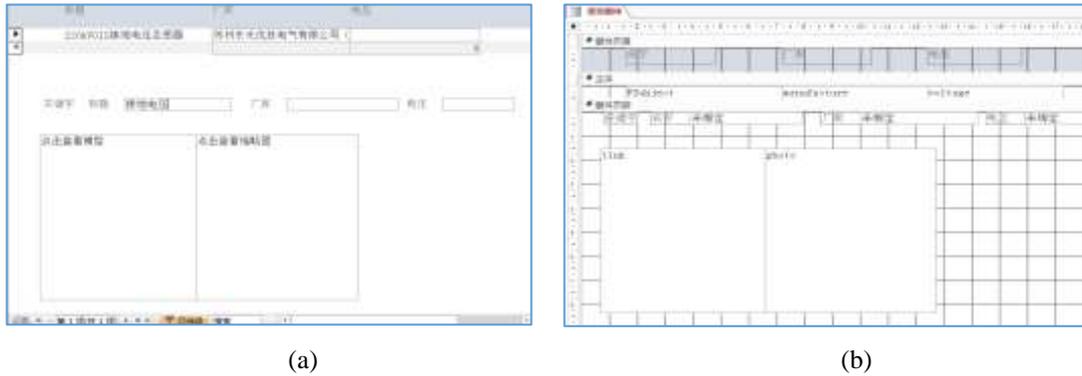
(a)　　　　　　　　　　　　　　　　　(b)

Figure 5. Query form creation. (a) Query function; (b) Database forms basic layout.

4.2.3. Traversal module. This module is used to traverse the model and its related information in the whole 3D model equipment library, and the tree structure can well meet this functional requirement.The tree view is created by ActiveX control, which is a program object that can be reused in applications and computers in the network.In this paper, Microsoft Imagelist control, version 6.0 and Microsoft treeview control version 6.0 in ActiveX control are used to create the substation 3D model tree view.

The Imagelist control is used to display the icons inside the tree view, and the treeview control is used to generate the tree view structure, which needs to be implemented with visual basic language. The typical methods are: add method, getvisi blecount method and ExpandAll method.Among them, the add method is the main use method of 3D model database in this paper. Its function is to add a node object to the nodes collection of treeview control. Its syntax structure is: object. Add (relative, relationship, key, text, image, selectedimage).Combined with the parent-child relationship created in the previous data table, the tree view of the three-dimensional model of substation equipment is shown in Figure 6.

Figure 6. Tree structure of electrical equipment.

Then, the query form created above is added to the main form as a sub form, and the query function of the main form is realized by combining the combo box control.The main form of the 3D model database is shown in Figure 7.
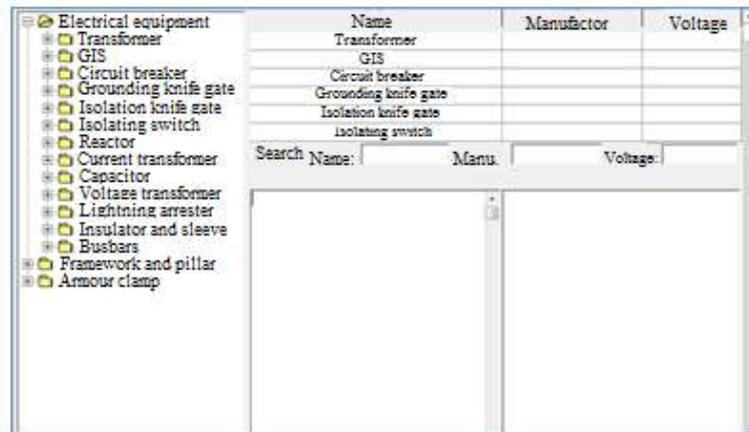
Figure 7. Main window layout.

5. Conclusion

Based on the analysis of the functional requirements and architecture design of the substation 3D model database, a simple and easy to learn model management and maintenance module and a human-computer interaction module are built based on access to realize the creation of the substation 3D model database. The database realizes the management of three-dimensional model of equipment, voltage level, manufacturer, equipment model and other information. It also provides a large number of reliable models for the three-dimensional design of substation, reduces the workload of three-dimensional design, greatly improves the work efficiency, and has certain engineering application value.

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