Research on 3D Visualization Algorithm of Digital Power Grid Based on GIS+BIM Dual Engine

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Abstract. Aiming at the problems of data fusion and visualization rendering in the grid engineering data platform, this paper starts from the two levels of data fusion and 3D visualization, studies how to use data to construct information entities, and pays attention to how to effectively fuse geographic information to realize the close fusion of BIM (Building Information Modeling) and GIS (Geographic Information System). By introducing related algorithms such as dynamic rendering, we realize the visual presentation of data in 3D space. This research is of great significance for the development of the data platform of digital grid, and provides new ideas and solutions for grid engineering management.

Keywords: data fusion; geographic entity; data model; BIM; GIS; Grid engineering

1 Introduction

The management of grid data and information services is an important part of digital grid construction. Due to the grid data has many types, large data volume, complex system, lack of unified norms and part of the data synergy slow and other characteristics, resulting in low efficiency of information display, information sharing and other problems, seriously hindering the construction of digital power grid. In order to open up the "information island", domestic scholars have conducted a lot of research on data fusion methods. Zhang Hongyan, ZhangYu, CaoCanming [1] solve the difficult problem of data fusion, the data is first processed, proposed a federal learning algorithm based on node optimization of data sharing clustering, the algorithm first uses the shared data and local data training convergence, based on the model parameters uploaded by each node to find similar nodes to carry out clustering operations. However, this method is highly demanding in terms of parameters and does not guarantee that similar nodes will be found. Hu Xiaojing, Yu Liu, Chen Yanbo, Li Shudan, Li Yao[2] used the classical iterative closest point (ICP) method to simplify the data, and then imported the data into ContextCapture for 3D scene construction after data fusion. However, iterative closest neighbor (ICP) consumes a lot of time and is not efficient. Furthermore, Ke Lin[3] realized the fast fusion of data by combining fuzzy C-mean clustering (FCM), Improved Firefly Algorithm (IFA) and

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Support Vector Machine (SVM), but a lot of precision is lost. Meanwhile, 3D visualization technology emerges as a powerful tool for handling grid data. This is because it not only provides a more intuitive and vivid way of presenting the data, but also helps users to understand the geographic information more deeply. Jijuan, Li En ,Yang Juan[4] et used Three.js to build a 3D visualization technique based on Web3D technology, and Cheng Pan, Yao Chunyu[5] et used a body rendering method based on light projection algorithm to realize 3D visualization. However, all of these methods above have a problem of low visualization accuracy. In summary, the data fusion methods have problems with accuracy or implementation difficulties, and the 3D visualization aspect cannot be visualized with higher accuracy.

For this reason, in this study, it takes grid data and geographic data as an example and proposes the following platform construction scheme, as is shown in Fig. 1.:

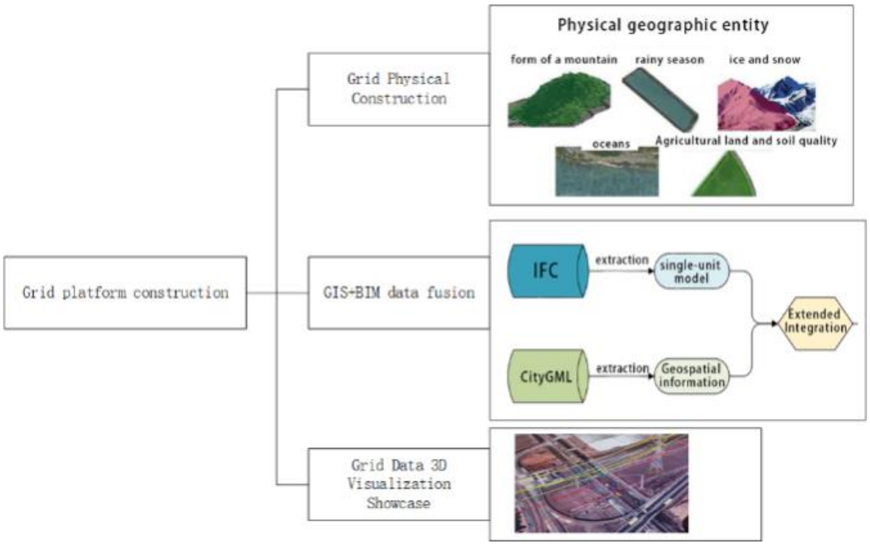

Fig. 1. Framework diagram for platform construction.

In Fig. 1. We introduce construction of the Grid platform. The platform is built by constructing grid components through entity coding and seamlessly fusing GIS+BIM data using a standard extension-based approach， This method bypasses the problem of finding parameters while ensuring some efficiency and accuracy. In addition, the rendering optimization using a wraparound sphere-based view cone culling algorithm is used to visualize the grid data to ensure that the constructed big data platform can effectively cope with the complex data fusion challenges. This method is a bit more accurate compared to the above method.

2 Geo-entity based BIM modeling

Geographic entities can present multiple forms of expression, including points, lines, surfaces, bodies, as well as images, point clouds and so on. Through the unique identification code of geographic entities[6], we can establish a bridge between different forms of data of the same entity, and realize the expression of the same geographic entity in multiple dimensions and forms, which is called "one multi-dimensional"[7]. In this paper, we utilize this feature to construct an entity repository.

2.1 Entities build data sources

The data sources for grid entity construction are shown in the TABLE 2, which mainly include 2D data such as fine model of buildings above ground in the BIM model, white model of buildings, 3D model of underground buildings, etc., geologic and meteorological data, geographic base maps, and vector artifacts.

2.2 Entity building ideas

Among all the data of the grid entities, there are geometric data that provide the geographic location of the buildings, topographic data, GIS data, etc., which provide the data base for the buildings that are the focus of the grid.

In order to accurately interface the grid engineering information with GIS for visualization, entity coding was performed for each data[8], so that each building block model corresponds to a unique code. A building block library of grid entities under different data conditions was established. The Entity classification construction is as shown in Table 1:

Table 1 Entity classification construction.

hierarchy	Professional Attributes	codes
1	image data	D0
2	Sensor data	D1
3	Geological data	D5
4	Hydrological data	D3
5	Meteorological data	D4
6	Model data	B0
7	Basic survey data	B1

Table 2 Entity construction data sources.

serial number	name	element	specification	purpose
1	image data	Satellite imagery, oblique photographic imagery	tiff、png、jpg、GeoTiff、img、gif、bmp, et al.	providing an important basis for the geographic positioning.
2	Transducers data	Pressure sensors, radar sensors ,Humidity sensors, etc.	txt、dat、brn、csv, et al	Provide information about the surrounding environment of the power grid.
3	Model data	BIM data, etc.	cgr、dwg、dxf、dwf、rvt、stp、vwx, et al	Provide building geographic location and 3D geometric data.

4	Hydrological data	Rainfall data, water quality data, etc.	csv、xls、json、hdf, et al	Provide information on the natural environment and geographic conditions near the grid, which is an important data base for the design, construction, operation and maintenance of transmission lines.
5	Meteorological data	Temperature data, and speed data, humidity data, etc.		
6	Geological data	Topographic and geomorphologic data, etc.		
7	Basic survey data	Topographic and geomorphologic data, GIS data, etc.	shp、kml、gml、dwg、dxf, et al	Provide topographic and land survey data, which plays an important role in tower siting and line design.

In this study, the information such as component name and data type is structured and stored, which not only provides support for the statistics of data, but also provides the

conditions for the fusion of data. The technical route of the grid entity building block library is as shown in Fig. 2:

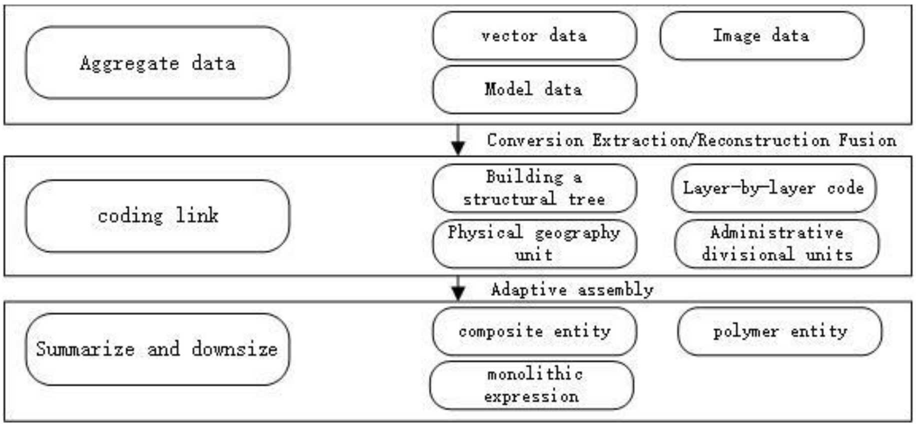

Fig. 2. Technological route.

In Fig. 2. We The technical route of the grid entity building block library, and the following methodology is used;

- Analyze or extract the grid entity component types and construct parametric component models. Make full use of the characteristics of "one-piece-multi-dimensional".
- Collect and organize the attribute information of each component type, including project information, operation and maintenance information, etc., and form the component attribute information standard.
- Creating component and attribute tables by categorization and using a layer-by-layer code system for coding grid components.

- Establish a structural tree-like organizational relationships, the components and the database for internal correlation, to achieve automatic identification and reading, and then realize the creation and invocation of the components library, to achieve rapid construction.

The core of the above idea is to realize the rapid construction and invocation of grid entities through the establishment of classification, coding and organizational relationships of grid entities, which in turn improves the efficiency and accuracy of communication in the grid sector.

3 Seamless integration of GIS and BIM data

GIS mainly focuses on geospatial information, while BIM focuses on building structures and components. Through the fusion of the two, the structure and attributes of buildings and infrastructures can be better understood in geospatial terms, and a more comprehensive and three-dimensional view of the information can be provided, which enables closer collaboration between people from different professional fields during the design, construction and management process. This section focuses on the fusion methods of BIM and GIS data. Combined with the literature [9-12] research, the data fusion methods of BIM and GIS mainly include three ways of data format conversion, standard extension and ontology-based technology integration.

In this study, we use a standard extension based approach to seamlessly integrate data from GIS and BIM with the following process:

- Firstly, the data in B0,B1 are extracted and the feature information is extracted.
- GIS-BIM data interaction is realized through the vectorization process, and the grid geomorphology data and GIS parameter information are obtained in the BIM platform, which indicates that the BIM data matches the GIS analysis results.
- Through the use of instantiation, lightweight processing and other performance optimization techniques, BIM + GIS information is efficiently integrated to improve the performance of the 3D scene, data transfer speed and visualization effect.

The pseudo-code is as follows:

```
// Obtaining data from GIS
gisData = gis.getData();
// Getting data from BIM
bimData = bim.getData();
// Data preprocessing
processedGisData = preprocess(gisData);
processedBimData = preprocess(bimData);
// data fusion
mergedData=mergeData(processedGisData,processedBimData);
// Display of fused data
```

displayData(mergedData);

4 Three-dimensional visualization of power grids

4.1 Texture mapping

The data sources required for grid data rendering mainly include 3D models such as BIM models and fine models of buildings on the ground. When dealing with 3D data, firstly, the geometric information, texture, material and other data of the 3D model need to be loaded. Secondly, the projected texture coordinates of the model vertex slices in pixel space within the viewfinder are determined by the principle of perspective projection, and the texture differences at the seams are eliminated with the help of texture blending [13]. The technical route is as shown Fig 3:

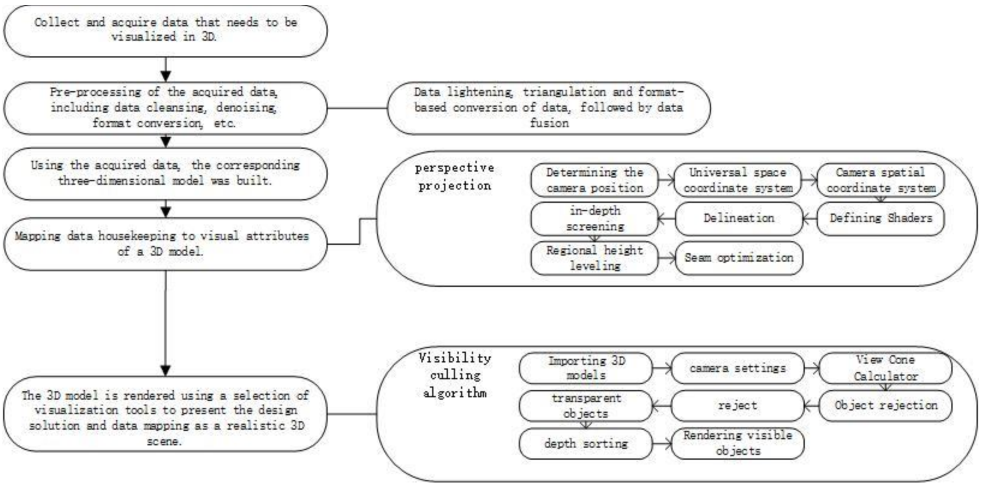

Fig. 3 Technological route.

The texture mapping scheme adopted in the paper is the perspective projection method, which is based on the following principles:

Let the 3D object tuple vertex have coordinates X_0 in the O-ENU coordinate system and X_W in the ECEF coordinate system, and the rotation translation transformation matrices are set to R_0 and T_0, respectively, then the world coordinates of the vertex, X_W is calculated as follows (1):

$$X_W = R_0 T_0 X_0 \tag{1}$$

World space to camera space. Let the vertex corresponds to the chi-square coordinate X_c in the camera coordinate system as (X_c, Y_c, Z_c, 1), then there is the following transformation relation.

$$\begin{bmatrix} X_c \\ Y_c \\ Z_c \\ 1 \end{bmatrix} = \begin{bmatrix} \mathbf{R}_w & \mathbf{T}_w \\ 0 & 1 \end{bmatrix} \begin{bmatrix} X_w \\ Y_w \\ Z_w \\ 1 \end{bmatrix} = \mathbf{E} \begin{bmatrix} X_w \\ Y_w \\ Z_w \\ 1 \end{bmatrix} \tag{2}$$

In (2) the dimensions of the matrix multiplication are compatible. $\mathbf{R}_w$ is the rotation matrix composed of camera outer parameters; $\mathbf{T}_w$ is the translation vector, which together form the outer reference matrix E. The texture mapping results are as shown in Fig. 4:

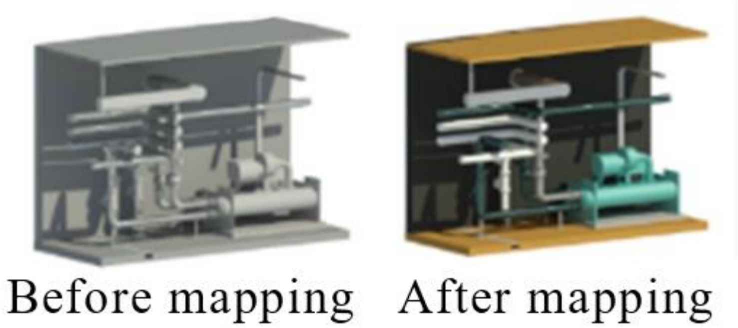

Fig. 4 Rendering of the wraparound sphere-based view cone culling algorithm.

4.2 Dynamic rendering

Since 3D models are mainly BIM models, they are usually more complex. If all the building blocks are rendered, it will significantly increase the burden on the GPU. Therefore, the building blocks in the model can be culled by visibility culling

algorithms. Among them, the wraparound sphere-based visibility cone culling algorithm is a relatively simple but effective visibility culling algorithm.

The enclosing ball is calculated as follows. the coordinates of point P(0， P_y) and P_y satisfies

$$P_y=\frac{f-n}{2}+n=\frac{f+n}{2} \tag{3}$$

The coordinates of point Q are (Q_x,Q_y), and Q_y = f, and Q_x is given by trigonometric functions.

$$\frac{Q_x}{f}=\tan\left(\frac{fov}{2}\right)\Rightarrow Q_x=f\cdot\tan\left(\frac{fov}{2}\right) \tag{4}$$

Therefore, the coordinates of point P can be expressed as (0，$\frac{(f+n)}{2}$), and the coordinates of point Q as (f, $f\cdot\tan\left(\frac{fov}{2}\right)$).The distance from point P to point Q is the radius R of the sphere surrounded by the sight cone, and according to the formula for the distance between two points, it can be obtained that:

$$R=\sqrt{f^2+\left(f\cdot\tan\left(\frac{fov}{2}\right)-\frac{f+n}{2}\right)^2} \tag{5}$$

The rendering results are as shown in Fig. 5:

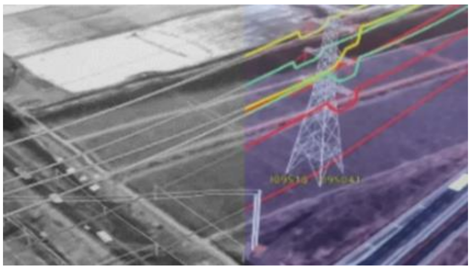

Fig. 5 Rendering of the wraparound sphere-based view cone culling algorithm.

5 Conclusion

In order to build a data fusion platform and avoid inefficient data management and insufficient sharing, this paper introduced the idea of constructing geographic entities, and adopts a standard extension-based approach to fusion GIS and BIM data. Finally, the perspective projection method and the wraparound sphere-based view cone culling algorithm are used for texture construction and real-time rendering, respectively. The application of these algorithms enables the 3D visualization of data in the digital grid. In order to realize the high efficiency and low cost construction of grid data sharing platform, it provides reference for the construction of grid data sharing platform.

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