A Study of Rural Site Design and Renovation in The Context of Computer Modeling

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Abstract: The community water supply and drainage network has the function of material transportation and wastewater removal, and is the "lifeline" to ensure the basic life of urban residents. With the advancement of smart communities, higher requirements are put forward for digital and information-based urban infrastructure construction. Most of the traditional 3D models of pipe networks cut off the indoor and outdoor areas, which cannot be visually expressed indoors and outdoors and are difficult to meet the actual needs. In practical management, users usually need to perform business analysis based on spatial data of pipe networks at different scales. Therefore, this paper studies the multi-scale modeling method of community water and drainage network according to the business management needs, and proposes to integrate BIM models of different levels of water and drainage network with 3D GIS, which realizes the visual representation of community water and drainage network integrating BIM and GIS, and can basically solve the problems of optimizing the business analysis of pipe network and improving the efficiency of visualization.

Keyword: Community water and drainage network; Multi-scale; Pipe Model Family Library; Visualization

1 Introduction

In recent years, as China continues to introduce relevant policies to support the construction and development of smart communities, 3D GIS and BIM technologies are gradually used to improve the management efficiency of community water and drainage networks. BIM technology and 3D GIS have their own advantages, and the integration of the two gives full play to their respective strengths, bringing a new approach to the management of different stages of urban pipe networks [1]. BIM technology provides detailed and highly refined building 3D model data, and 3D GIS technology satisfies 3D spatial application analysis in the geographic environment, and the integration of the two improves the digital city whole life cycle information management [2]. However, in the practical management of the planning, design, operation and maintenance of water and drainage networks, users usually need spatial data of different scales for business analysis. For example, when carrying out maintenance of indoor or underground drainage network, managers prefer to obtain accurate and real fine 3D models of spatial locations; while when planning for drainage network, managers only need to understand the overall layout of the drainage network, pipelines, and pipe point directions [3].

ICIDDT 2023, November 03-05, Zhenjiang, People's Republic of China

DOI 10.4108/eai.3-11-2023.2342148

2 Pipe network data reading test

2.1 Experimental environment

For the problems of diversified formats, scattered storage, and inconvenient use of the basic data of community water supply and drainage network, this experiment reads and tests the data of the previously constructed pipe network model in order to facilitate centralized and unified storage and management and realize the utilization of data [4]. This experiment is developed in Java as the development language, using IntelliJIDEA software, using PostgreSQL as the target database, using pgadmin4 to assist in management, and installing JDBC API drivers and such like drivers [5]. PostgreSQL not only supports most SQL standards and provides complex query function features, but also has a high degree of scalability, compatibility also supports ArcGIS, SuperMap and other GIS spatial analysis software for connection, which can directly connect to access the data in the PostgreSQL database to effectively and conveniently process spatial data for 3D spatial analysis. JDBC is used for development and design to interact with the database. JDBC consists of classes and interfaces written in the Java language that can be used to execute SQL statements in the Java API, which provides methods to query and update data in the database. the JDBC API provides an interface to the Java language to access the database, and users can design complete database applications [6].

2.2 Pipe network data reading test design

The classification of community water and drainage network elements and entity objects are determined, and the construction process of the multi-scale model of community water and drainage network is elaborated. This paper will use the semantic information of the constructed 3D model of community water and drainage network as the data for experiments. In this paper, we first set up a PostgreSQL database, use the Java JDBC interface to connect to the database, and use the Java language to write a simple version of the pipe network data reading test program on the interface. The specific design process is mainly: (1) through the Revit development environment, using SQL statements to extract the geometric and semantic information of community water supply and drainage pipe network LOD200-LOD400 level model fittings, pipes and building elements, and export them to CSV files respectively [7]; (2) install JDBC API driver in the local computer, through Partial Java JDBC Driver conversion, the JDBC API used in the Java program into Native API, and then store the database; (3) through pgadmin4 auxiliary management, using Java JDBC interface to connect to the database to complete the design of the pipe network data reading test program; (4) Add Java Swing JFrame graphical window interface to achieve The interactive interface to meet user requirements [8].

2.3 Test function implementation

The interactive interface is the channel for information exchange between human and computer. Users can actually input of the information of pipe network data through the interactive interface to perform relevant operations according to their needs. Users through this experiment designed interactive interface to achieve the data query data, timely update and other operations [9]. The specific functions are realized as follows:

(1) Data query function;

(2) Data update and modification function;

(3) Delete data, when the actual project works to remove a pipeline or pipe point, you can delete the corresponding property information in the application;

(4) Import data and export function [10].

In this experiment, we mainly query, add, delete and improve the community pipe network attribute data, and read and test the pipe type, family type, size, material and other information in the pipe network attribute data; at the same time, we update and import the data of new pipes and fittings in a timely manner, forming timely and accurate data in line with the actual project on site, providing accurate and real attribute data for community water supply and drainage visualization and application [11].

3 Three-dimensional tile data format

3.1 Introduction of 3DTiles

The proposed 3D tile model enhances the ability of GIS to visualize spatial data. 3D Tiles is an open specification for integrating large-scale multi-source heterogeneous 3D geospatial data for visualization, fusion and shared interaction on PC, mobile and Web, with the main purpose of improving the loading and visualization rendering rate of large 3D model data.

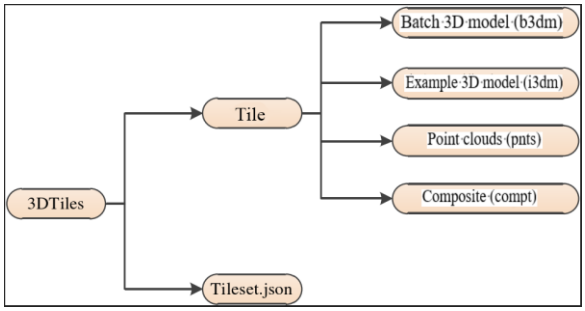

Figure 1: 3DTiles data basic logic structure

From the introduction of 3D Tiles definition data content above, we can find that the definition of 3D Tiles itself has abstraction, and this abstraction makes 3D Tiles super compatible, thus making the concept mapping free, tile indexing mechanism free, position transformation mechanism diverse, detail level configuration diverse and attribute data configuration diverse, etc. The 3D Tiles data format is specifically designed for use in Cesium's 3D applications, and ultimately has to be used in Cesium to reflect the value of the tile data itself.

3.2 B3dm tile

Since the model constructed in this paper is a 3D BIM model of large number of community water supply and drainage networks containing water users, this paper describes the tile batch 3D model (b3dm) required below. The b3dm tiles are the more frequently used and most versatile type of tile data in 3D Tiles, officially defined as bulk 3D models used primarily for the interior and exterior of 3D building models, models with large data volumes, and stored textured terrain surfaces. Therefore, for the BIM model data of community water user buildings

with complex exterior and interior structures, it is more suitable to be stored in b3dm tiles. The b3dm single tile can contain single or multiple models, enabling efficient completion of Web GL drawing call tasks by transferring multiple models in a single request during model rendering.

4 Community water and drainage network BIM model conversion 3D tile

4.1 Experimental protocol

In order to verify the effectiveness of the multi-scale community water supply and drainage network designed in this paper, the multi-scale BIM model of the community water supply and drainage network constructed is converted into 3D tile data using plug-ins to achieve 3D visual representation.

(1) BimAngle Engine for Revit

BimAngle Engine is a powerful lightweight data engine, which includes BimAngle Cloud and BimAngle Browse, enabling automatic server-side background conversion, fast model preview without complex deployment, reduced data redundancy and thus lightweight, and improved data loading speed. Engine (BimAngle Engine) supports different data formats and rendering performance, and provides rich functions and integration methods based on the ability to quickly convert and output BIM model data, so that users can choose the appropriate integration method according to actual needs and different business scenarios.

(2) WebGL

WebGL is a 3D drawing technology that displays 3D scenes and models smoothly in the browser and allows the user to interact with them to some extent. With the development of WebGL technology with open source and unified standards, good compatibility, lightweight and no plug-ins and zero compilation characteristics, the current stage of common three-dimensional engine are Cesium, Three.js, WebGLEarth, OpenWebGLobe and so on. This paper uses Cesium, a 3D geo-virtual platform developed by AGI (Analytical Graphics Inc), to render the 3D tile data elements of community water and drainage networks. Cesium's development language is object-oriented JavaScript, which can be integrated with frameworks such as WhenJS and KnockoutJS to encapsulate the functionality of AJAX, which in turn enables asynchronous requests for massive amounts of spatial data on the server side.

4.2 Three-dimensional tile acquisition method

It can be seen from the above that BIM models of drainage network components at different LOD levels are constructed in this paper, but their spatial analysis capabilities are weak and the data formats are incompatible with each other, making it difficult to achieve information sharing. Therefore, data integration is needed for visual representation of the drainage network. The method of data integration is usually the format conversion of data, so this paper converts the elemental model of community water and drainage network into Cesium-supported data by means of data format conversion.

5 3D visualization of community water and drainage network

5.1 Community water and drainage network elements of three-dimensional tile transparency

Cesium3D Tileset loaded into Scene using Cesium. The pipeline system model appears to be offset. The reason for the offset may be because the model does not match the real location, or the coordinates of the piping system model and the exterior building model are not consistent when modeling in Revit software, and the coordinates used to convert the 3D tile data format are the coordinates used to link the piping system model to the interior of the building through model integration to form a complete BIM model of the water supply and drainage network of the residential building.

The model offset problem is solved below by dynamically loading the modelMatrix to create a planar matrix. First obtain the offset:

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & T_x \\ 0 & 1 & 0 & T_y \\ 0 & 0 & 1 & T_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} \quad (1)$$

According to Equation 1, the translation matrix modelMatrix is obtained by setting the m matrix and dynamically adjusting the size of x, y, and z. The translation core code is shown in Table 1.

Table 1: Translation matrix code

Translation matrix code
//Pan matrix
var m = Cesium.Matrix4. fromArray ([
1.0, 0.0, 0.0, 0.0,
0.0, 1.0, 0.0, 0.0,
0.0, 0.0, 1.0, 0.0,
-4.275, 1.4057, -3.66, -1.2,
]);
//
var toolbar = document.getElementById("toolbar");
Cesium.knockout.applyBindings(viewModel, toolbar);
const tileset1 = new Cesium.Cesium3D Tileset({
url:"../../SampleData/Cesium3DTiles/Tilesets/ Drainage tile data/tileset.json",
maximumScreenSpaceError: 2, // Maximum screen space error
maximumNumberOfLoadedTiles: 1000, // Maximum number of tiles loaded
//Pan matrix
modelMatrix: m
modelMatrix: m

The effect after adjusting the center position of the model by the above translation matrix, the piping system model is panned to the corresponding position in the building interior, i.e., the piping system model of the 3D tile is consistent with the coordinates of the building exterior model, thus solving the problem of the model offset problem.

5.2 Community water and drainage network 3D tile model cutting

You cannot use the screen coordinates as the basis for moving the cutting surface on the side, because when rotating the model, the direction of the cutting surface movement and the direction of the mouse movement will change with positive and negative values resulting in the opposite. You can solve the problem of moving in the opposite direction by getting the earth coordinates, converting them to latitude and longitude, and then using the difference in latitude and longitude when the mouse moves as the basis for moving the side cut. The effect of residential building cutting is shown in Figure 2- Figure 4.

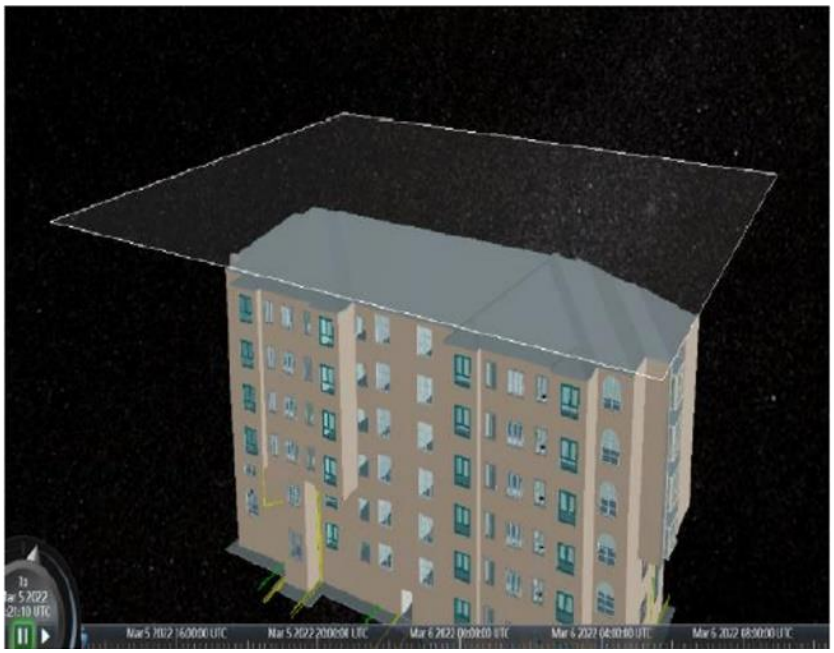

Figure 2: 3D tile model visualization before cutting

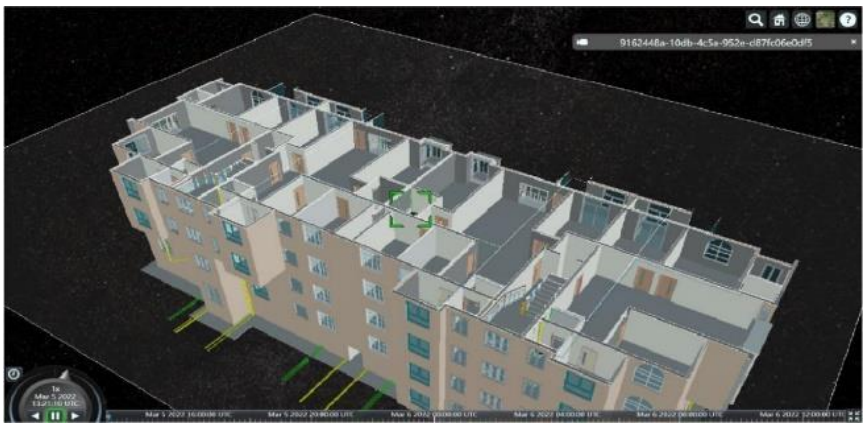

Figure 3: 3D tile model visualization after cutting

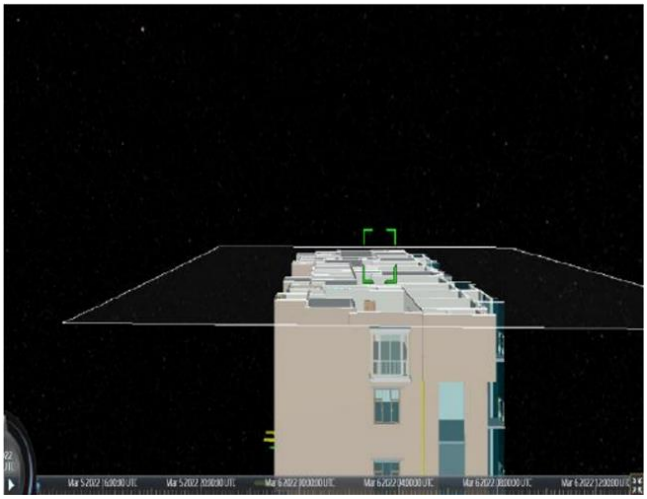

Figure 4: Residential building 3D tile model cut and enlarged

6 Conclusion

This paper mainly verifies the feasibility of the multi-scale model of community water supply and drainage network designed in this paper through experiments. Based on the community water supply and drainage network data model constructed in the previous paper, this paper realizes the operations of adding, deleting, changing and checking data by designing the non-spatial database of the pipe network; converts the BIM model data into 3D Tiles data for large-scale rendering on the Web side, introduces the tile dataset structure and data conversion tools, converts the BIM model data to the metadata tileset.json and tile b3dm conversion, and the use of metadata design flexibility, the scene of the residential building water supply and drainage network and water supply facilities metadata space nested expansion, to achieve a reasonable organization of the community water supply and drainage network model at all levels and transfer readings. According to the demand, through the design based on Cesium using JavaScript, HTML and CSS, the architectural elements of the community water and drainage network were visualized by floor cropping and pipe highlighting transparency, so that users can directly view the pipe network elements on each floor or the pipes inside the whole building. Finally, the community water and drainage network model data model is imported into SuperMap for integration, and the basic functions in pipe network management were realized: measurement analysis including spatial distance and area calculation, profile analysis and attribute query, etc. It proved that the multi-scale model of community water and drainage network in the study meets the needs of users to a certain extent.

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