The Research of Virtual Campus Indoor 3D Modeling and Analysis

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Abstract

With the development of virtual reality, Indoor 3D modeling and analysis is getting more and more attention. This paper mainly studies the design principle of 3D modeling interior scene, the design of building interior scene, and the key technologies of interior modeling, including data acquisition and processing, the establishment of white model, the construction of fine model, model quality inspection,and indoor 3D model visualization, 3D shortest path analysis. Taking the teaching building of Sanxing Building of Taiyuan Normal University as an example, research on three-dimensional indoor modeling and shortest path analysis, A shortest path analysis model is established. The results show that the method can be used for indoor modeling and shortest path analysis. Combining indoor modeling with GIS can give full play to their advantages.Compared with 2D shortest path analysis, 3D shortest path analysis can be used for shortest path analysis in 3D environment, such as application in 3D indoor model.The research results have some reference value for indoor 3D modeling and 3D shortest path analysis.

Keywords

Indoor 3D modeling; 3D visualization;three-dimensional shortest path analysis.

1. Introduction

With the development of virtual reality technology, three-dimensional modeling has attracted more and more attention. At present, the study of three-dimensional modeling is more about building surface and environment modeling,combing SketchUp with ArcGIS for modeling and visualization[1-2], using 3DMax and SkyLine, SuperMap for modeling and visualization[3]. There are fewer indoor models. More models show the existing environment through modeling, and less integrated with the analysis function of GIS.

Indoor three-dimensional modeling technology is widely used in smart city and three-dimensional virtual scene, and its application prospect is broad. And indoor three-dimensional modeling technology has great practical value.Firstly, in the emergency response, it can accurately locate the people to be rescued, from the plane position of the building to the floor or room number. In addition, indoor navigation is based on indoor positioning and it's purpose is to find an optimal path and provide guidance or cognition to users,which combing map information and according to the existing location and destination. So indoor path analysis has gradually become a hot topic.

In the research of indoor modeling,Wu[4]studies the modeling method of indoor three-dimensional, and designs the three-dimensional navigation algorithm and path planning flow. The scholar[5] adopts multi-view image to model indoor three-dimensional scene, uses feature extraction operator to extract and match indoor image feature points, extracts feature points and lines, establishes indoor wireframe model and solid model to construct a three-dimensional scene mode.Some scholar[6-9]adopt Mobile lidar to acquire indoor point cloud data, and general modeling software was used for indoor three-dimensional modeling. Mobile lidar can acquire accurate point cloud data, the model built by it is of high precision. An indoor three-dimensional modeling method combining Kinect point cloud

and image data was proposed[10-12]. literature[13]vectorized the interior plan and built the building model efficiently. The method of automatically constructing the model by image is put forward in reference[14-15].

Foreign scholars have also studied three-dimensional modeling.Airborne laser scanning data is also used in automated urban modeling[16].An improved LOD specification for 3D building models[17]. Imagery and Point Clouds is used to 3D Modeling of Building Indoor Spaces and Closed Doors literature,the development of automatic approaches for reconstructing 3D indoors from imagery and/or point clouds can make the process easier, faster and cheaper[18].

Traditional network analysis, such as path analysis, realizes the function of network analysis in two-dimensional environment, but it is difficult to realize the function of three-dimensional network analysis in building interior.

In this paper, three-dimensional modeling and path analysis are studied. Indoor modeling using CAD structural diagram, Some key technologies have been studied. The indoor modeling and visualization of the three-dimensional building of Taiyuan Normal University teaching building and the analysis of the shortest path are carried out. The teaching building has eight entrances and exits, which are intricate. This paper studies the modeling of large and complex indoor buildings, establishes a three-dimensional path analysis model, realizes the function of shortest path analysis, and provides technical support for indoor modeling and the application of three-dimensional path analysis.The path analysis of high-rise buildings such as teaching buildings can not only be used for indoor navigation of campus teaching buildings, but also can be used to support the decision-making of evacuation in emergency situations, which has certain practical significance.

2. Design of indoor scene

2.1 The design principle of indoor scene

(1) Determine the framework of the building scene hierarchically

The model data contained in indoor scenes are numerous and complicated. In order to ensure that the final scene model is reasonable and orderly, hierarchical thinking is used for modeling. From the overall to the local, the entire large scene is divided step by step, and the scene frame structure of each floor is determined hierarchically, that is, the columns and walls in the scene. First, the general skeleton of the scene is built, and then each layer of the model is overlaid, forming a complete 3D model building framework.

(2) Refine the scene, enrich scene elements hierarchically, and model respectively

On the basis of the layered framework of building scenes, refine the scenes at each level, and enrich the scene elements. In addition, some elements(doors, windows, floors, roofs, fences, vertical traffic systems-staircases and horizontal transportation systems-corridors) are modeled and placed in the scenes of each layer according to the location measured in the field.

(3) Simplify the scene, highlight the key point

The interior scene design of virtual campus is the first task that modelers must complete before modeling, and it is also a key step in the modeling work. Whether the scene design is reasonable or not may influence the quality of the interior model in the future and the degree of truth. In order to reflect the real environment within the building, the modeler has to optimize the scene design continually to make the model more perfect.

2.2 The interior scene design of building

Virtual Campus Interior scene design is the primary task of modeling before modeling, and is also the key step of modeling work. Whether the scene design is reasonable or not is related to the quality and the true degree of the indoor model in the future. In order to make the indoor model better reflect the real environment in the building, Only by constantly optimizing the scene design can the modeler perfect the texture of the model.

Owing to diverse scenes, an amount of data and complicated modelling process, the designer must clarify the structure of each layer, all levels, and nodes of the building, plan the layout scene reasonably and understand what it is. Additionally, it is necessary to adjust the environment continuously and establish a reasonable and orderly indoor scene eventually.
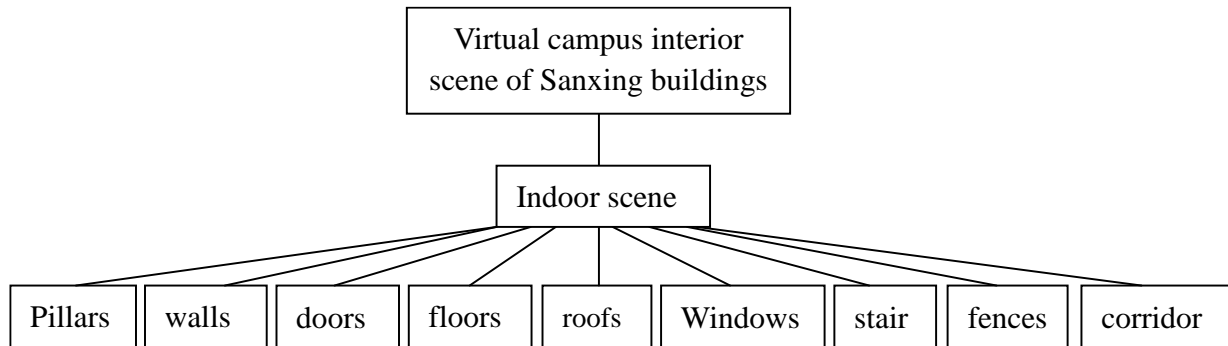

Fig.1 Interior scene design

3. Indoor modelling

3.1 Data acquisition and processing

The basic data of indoor modeling includes:location information of the building terrain, building structure information, and texture data. This paper takes Sanxing building of Taiyuan Normal University as an example to model.

Geographical location information

Based on the field survey of the Sanxing building and the CAD graphics of campus, the geographical location and attribute information of the Sanxing building were obtained, including the height, the number of floors, the general structure of Sanxing building, and the specific location and distribution of four groups (northeast, southeast, northwest and southwest).

The structure information of the building

First, apply for a detailed CAD drawing of the individual buildings (a total of six floors including the roof) of the Sanxing building, including the architectural CAD drawing, the CAD drawing of the teaching building structure,etc. Secondly, we have obtained guide layouts for the classroom layout at each floor of Sanxing building to analyze and determine the specific location of the classrooms for reference in modeling. Finally, the acquired CAD data is carefully examined, analyzed, and combined with on-site inspections to determine the structural layout of the teaching building interior to ensure the accuracy of the following modeling, which enables the three-dimensional model to accurately express the indoor and outdoor structures of the Sanxing building.

Texture data

The building texture collection of the Sanxing building was taken. The photographs of the facades of the interior of the Sanxing building were photographed to obtain textures of each node of the building(windows, doors, stairs, etc.). Photographs were processed, including object extraction, resolution, size, format adjustment, etc., which aims for obtaining a map that can express the real texture information of the building and meet the specification of the map. In addition, collect some of the existing texture library materials, windows and door textures for modeling use.

3.2 3D modeling

3.2.1 Import of CAD data

Non-modelling contents in CAD drawings, such as labels, text, and fill patterns, are deleted to ensure that the basemap is complete, and the amount of CAD file data is reduced. When the CAD drawing is imported into the SketchUp software, layers and features may be missing. To avoid this phenomenon, the processed CAD drawing is generally saved in the t3 format,set the unit to mm before

importing. which is conducive to guarantee that the building height is stretched according to its actual size when the CAD plan is stretched into a 3D model[1].

3.2.2 Establishment of white model

(1) Collecting lines according to the outline of the building. The vectorization of the building outlines in the CAD drawing is automatically generated by the line connection to form a closed figure.

(2) Build a frame structure and a wall. The body frame of the building is stretched by using a stretch tool in a closed plane formed by the contour lines as Fig.2. When the body block is stretched, the building height can be set based on the actual value. Then, a horizontal and vertical traffic system was constructed. On the basis of the building frame model, the vertical traffic system of the Sanxing building(staircase) and horizontal traffic system(corridor) was built up to complete the construction of the model skeleton.
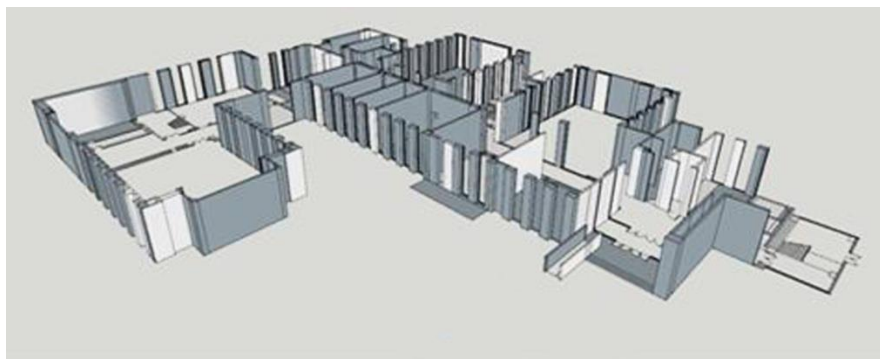

Fig.2 Framework of Sanxing building

Fig.3 The white model of Sanxing building

(3) Refine the scene, construct the door, window and other details with editing tools, and then package the modeling models of each layer together, so as to get the complete three-dimensional model of the building and complete the construction of the white model of building.

3.2.3 the construction of fine model

After the white model is made, it is necessary to give texture information to each side of the building to show the real conditions of the building. The material tool is used to assign the processed texture maps to the selected patches. Finally, the model is stored in the skp6 data format to complete the fine modeling as shown in Fig.4[13].

Fig.4 The indoor model of Sanxing building

3.2.4 Model quality inspection, correction, output

After completing the establishment of indoor modeling, it is important for the entire model to carry out the quality inspection, optimization model and the reduction of data, and output after saving. Exclude unnecessary lines and redundant faces in the model; modify individual models that do not meet the modeling standards in the entire model until they meet the modeling standards; a single model that has been severely unqualified will be deleted and rebuilt, making the final model is the most refined and simplest. While ensuring the fineness of the model, the quality of the model is improved and the model is optimized.

4. Visualization of indoor model

4.1 Import of the model

The model created in the SketchUp software is converted to the 3ds format and then interacts with the ArcScene platform. Name the model English when exporting, and save the 3ds file, texture file, and model file in the same folder to prevent loss of model texture. Create a new personal database in ArcCatalog and a point feature in the database(Multipatch type), load it into ArcScene,open the style manager in ArcScene, create a new style, and import the previously saved 3ds format model as a 3D tag symbol into the symbol library. If there are multiple models, they are added in this way. Therefore, a custom 3D symbol library is established. Modify point symbol style in the database, the original default point symbol is replaced with a custom 3D marker symbol[2].

4.2 Visualization of 3D model scene

After the model is successfully imported into ArcSence, it is necessary to design its own scene roaming route before the roaming visualization of indoor and outdoor buildings in Sanxing building.

You can use fly, roaming, bird's-eye view and other tools to view 3D scenes and roam the entire scene to learn about the indoor and outdoor conditions of Sanxing teaching building in ArcScene. The visual path that designed based on the scenario roadmap is displayed in ArcScene and saved as AVI video output. Fig.5 shows the indoor visualization scene of the Sanxing building. The outdoor scene of Sanxing building is present in Fig.6.

5. Three-dimensional shortest path analyses

It is necessary to set up network dataset for three-dimensional shortest path analysis, just like two-dimensional shortest path analysis.3D network datasets can be used to build models for internal structures such as buildings. A network is a system of interconnected elements, such as edges (lines) and points (points), which represents the possible paths from one location to another. People, resources and goods can travel along the network. By using the network to construct a potential path model, we can perform the analysis related to the movement of objects in the flow direction of the network. The shortest path adopts Dijkstra algorithm.
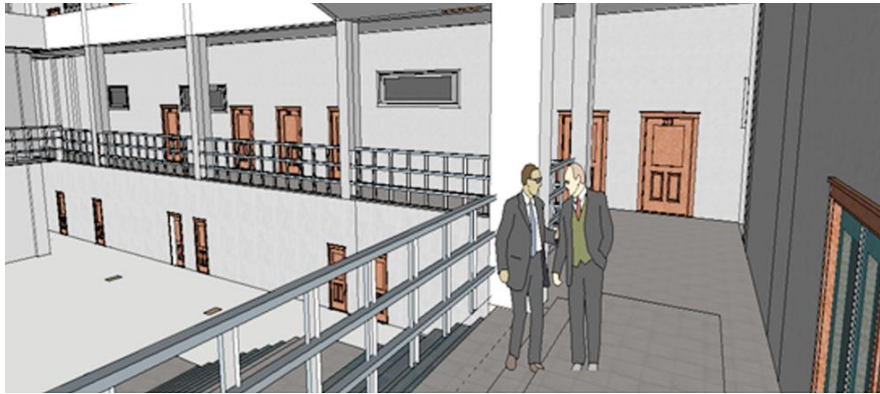
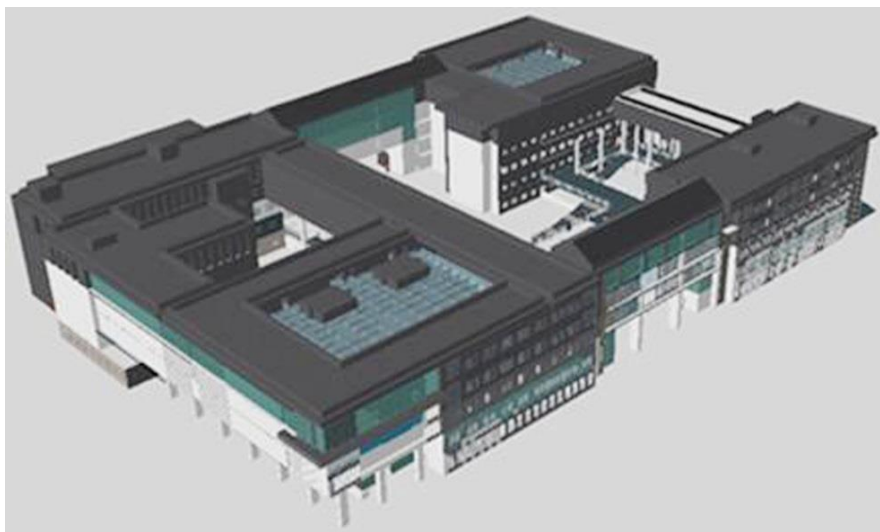Fig.5 Visualization of indoor scene of Sanxingteachingbuilding

Fig.6 Visualization of outdoor scene of Sanxing building

5.1 Acquisition of 3D network data

(1) Using the existing Sanxing Building model, each floor, indoor staircase and outdoor staircase are vectorized in SketchUp software, and a separate layer is established for each floor. The five floors are vectorized by the same method, and the data are connected through the staircase. Finally, the line model is formed, which is stored as dxf file and imported into Arcmap.By editing the attributes of each line element in ArcMap, the channel data of each floor, indoor staircase and outdoor staircase data are extracted.

(2) Building internal data: The database is established in ArcMap software, and the feature class of line, polygon and multipath is created, five-story corridor line data and staircase data are imported into the feature class-line, and the surface data of five-story classroom or office room are imported into the feature class of polygon. This data serves as a source feature class for creating a three-dimensional dataset.The vector data above is imported into ArcScene to form three-dimensional network data.

5.2 Creation of 3D network dataset

The three-dimensional network dataset is built according to the above source elements, which is similar to the construction of two-dimensional network dataset.When the system prompts "how to model the elevation of network elements?",select the Z coordinate value of geometry. After the creation and construction of the 3D network dataset is completed, the network analysis can be performed using the dataset.

5.3 Modeling of adding location

The network analysis-shortest path analysis under the created 3D network dataset need to be completed in ArcScene. According to the flow of two-dimensional shortest path analysis including adding network dataset, making route layer, adding location and solving,the analysis shows that the shortest path analysis in 3D is generally the same,but because the function of interactively adding location can not be realized directly in ArcScene, the spatial modeling process of adding location is built through Model Builder. Thus, the function of the shortest path analysis under the indoor three-dimensional model can be realized. The modeling process for adding location is shown in Fig.7.
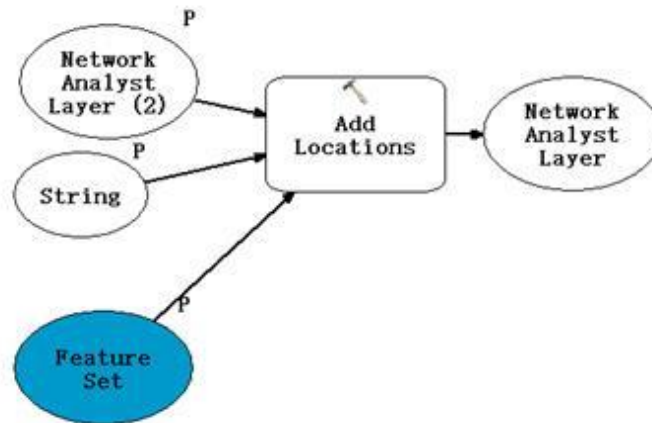

Fig.7 The modeling process for adding location

5.4 Shortest path analysis

Using the analysis model, first make route layer, then add two stops by using the model tool of adding location, input the constructed 3D network dataset.After the solution is determined, the model will calculate the shortest path and add the results to the map display as shown in Fig. 8. Path features will also be added to the route feature class in the table of contents. The thick green line in the Fig. 8 is the result of the shortest path analysis.
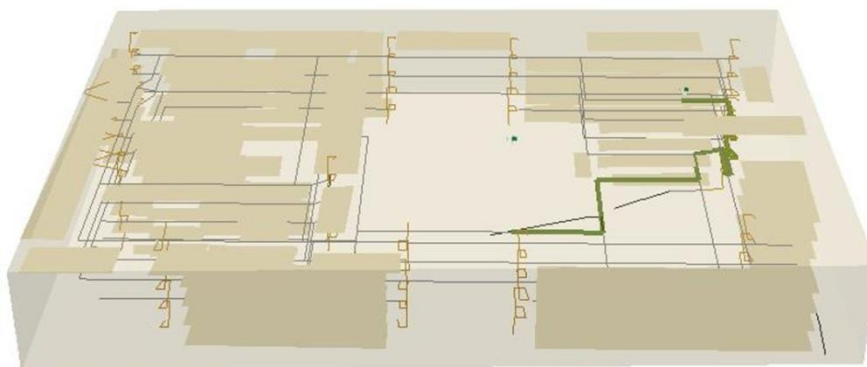

Fig. 8 Shortest path graphic

5.5 The integration and application of entity model and wireframe model

By integrating the built entity model with the line model of constructing the network dataset, the shortest path analysis can be carried out in the three-dimensional model, such as the shortest path from an entrance to the classroom, which brings convenience to travel. Meanwhile, fire simulation analysis can be carried out, which means that the shortest escape path can be simulated when a fire occurs.
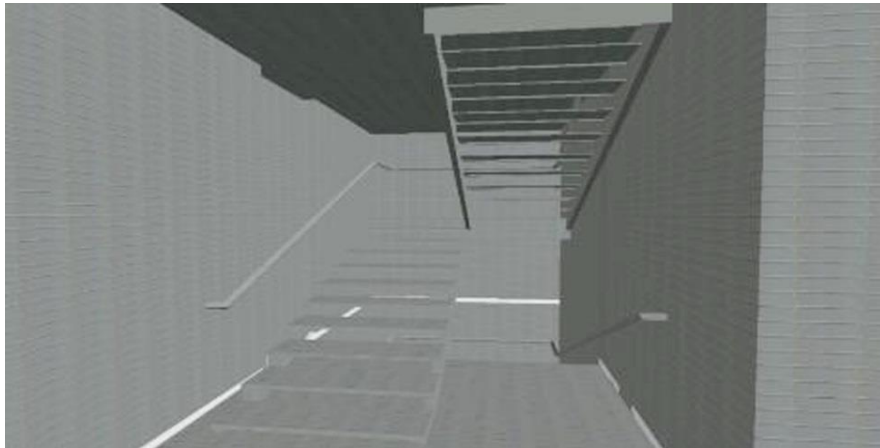
Fig. 9 Effect of model and network path fitting

6. Conclusion

This paper studies the indoor modeling of large teaching building and shortest path analysis.The interior model is hierarchical modeling by using the existing CAD structure drawings.We can get the following conclusions:(1) Compared with the use of measuring instruments to obtain data for modeling, this method is relatively simple, and can be used for indoor modeling that does not require too much precision.It is also possible to acquire data using a measuring instrument such as a three-dimensional laser scanner, and then use the method to perform modeling based on the acquired accurate data. (2) The current application of shortest path analysis is mainly done in a two-dimensional environment, and there are still few three-dimensional shortest path analysis. Our research has made breakthroughs in 3D shortest path analysis, and establish a three-dimensional shortest path analysis model. The establishment of this model improves the efficiency of the generation of the shortest path.

Acknowledgments

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