True 3D Surface Feature Visualization Design and Realization with MapGIS K9

Yuan Yuan, Shao Chun-fu, Ji Xun, Xiang Huaikun and Zhang Wenji

Abstract In the True 3D GIS system, obtaining and modeling of 3D geometric data is the key problem. This paper studies the concept, steps, and method of designing and realizing true 3D visualized campus map with MapGIS K9 software, Daogle Google interceptor, 3DMAX, Photoshop, enhancing the acquisition speed of 3D geometric data and solving the problems such as integration of MapGIS K9 software and 3DMAX software models with Shenzhen Polytechnic as an example to realize the 3D visualized campus.

Keywords True 3D GIS · MapGIS K9 · 3DMAX · Daogle Google interceptor · Map

Introduction

True 3D Volumetric Display Technique is a computer stereo display technology, which can directly observe the 3D images with physical depth of field. Since the true 3D model is nearly identical with the reality environment, it can bring a strong and life-like sensory shock to the users so that they can feel personally on the scene. Users can roam freely in a true 3D scene. The true 3D GIS takes the 3D space

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coordinates (x,y,z) as independent parameters to conduct geometric modeling for spatial entity objects, whose mathematic expression is $F = f\ (x,y,z)$. The model established in this way not only can realize true 3D visualization, but also can be used for 3D space analysis [1]. It indicates that the true 3D GIS is more realistic than previous 2D and 2.5D, which can observe the objects from each direction. Meanwhile, the true 3D GIS is also equipped with the functions of common GIS like collecting, storing, managing, analyzing, and displaying the spatial and nonspatial data.

Currently, there are several trends in the production of 3D scenes. In the first trend, ARCGIS and SketchUP are used for modeling based on WGS1984 coordinate system. Total station +RTK is used to measure and acquire the surface feature plan in the format of CASS CAD and the data of surface elevation points. Meanwhile, remote elevation measurement is employed to acquire the data of top elevation of surface features [2]. Though the plan data of surface features can be acquired from the digitized mapping with a total station, the method is time consuming and heavy in work load. Besides, ARCGIS is famous for long in the industry as a foreign software, but it is much more expensive than MapGIS K9, a domestic software with similar functions. In the second trend, the vehicle-mounted laser scanning system and GPS are adopted at the surface to figure out the outline and geographic data of surface features through ranging. The advantage is that the speed to acquire information is fast, the geometric information acquired is rather precise. The disadvantage is the work load is heavy and the rent of vehicle-mounted laser scanning system and later handling expense are quite expensive. In the third trend, with the planning map of surface features as the blueprint, AutoCAD software is used to draw the plan of surface features, import the plan into a 3DMAX software and draw a 3D model in an equal proportion. The 3D map of surface features established in this way cannot be called as true 3D GIS, because the 3DMAX software platform has not the functions for analyzing and checking the spatial information.

Technology Routine for True 3D Visualization of Surface Features

Based on MapGIS K9, 3DMAX and Daogle software, this paper designs a new technology routine for the production of true 3D visualization of surface features.

Namely, first Daogle Google interceptor is applied to intercept Google map with information of longitude and latitude and topographic map with the information of elevation. And then, GPS gauge is used to measure 4 typical coordinate points of surface features and correct the base map. And then MapGIS K9 software is adopted to produce 2D sector base map and edit it by entering the traits of each surface feature such as name, usage, and elevation and conduct the texture production and the production of a true 3D model of surface features. Finally, the

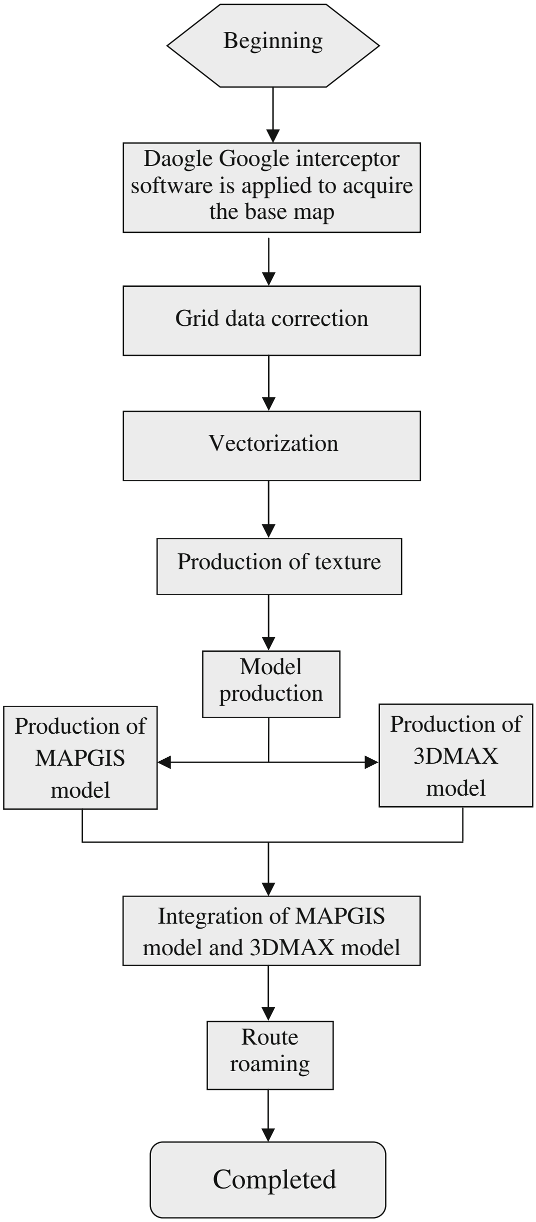

Fig. 1 Technology routine for true 3D visualization of surface features

3DMAX software is adopted for the production of other models. And then, the 3DMAX model and MapGIS K9 3D scene is integrated to get the true 3D visualization of surface features. This method has solved the heavy workload in adopting a total station +RTK to measure and get the base map of campus and high cost of ARCGIS software, and also solved the heavy workload and high cost in the rent of a laser scanner + GPS position finder, which has truly solved the coordinate problem of true 3D surface features (x,y,z) with high efficiency and low cost. The technology routine is shown in Fig. 1.

Production of True 3D Virtual Scene of Surface Features

1. Pre-treatment

(1) Image Data Treatment

The image downloaded with "Daogle Google Map interceptor" is imported into the database. We can see that the image is red and the texture of the architectures is not so clear. Therefore, we need to treat it in the "remote sensing treatment system," choose the "color setting" and re-set the "R,G,B wave bands" to change the color of the image.

(2) Texture Data Treatment

The object of surface features is photographed to collect texture. PS software is mainly used for image cut, rotation, and modification, and finally reaches a real effect of surface features.

For example, in creating the transparent texture, the final display effect of the fencing needs to be hollowed out, which should be displayed to be hollowed out from different perspectives. Here, we will show how to display the texture of a 2D photo into the 3D hollowed out effect.

Get a sample picture of the fence, and then use Photoshop software to extract the contents from the picture for the texture creation. Remove the white background in the picture and only retain the contour of the fence. In the output of the picture, save the picture in the format of PNG, so it can remove the white background. If it is saved into other common formats such as JPEG, the background will be filled with white. In the 3D landscape platform, edit the texture, newly build the texture, and set the "alpha testing" information of the texture parameters. (Testing function): passed if larger or equal to. (Reference value): 100. After saving, the texture is then transparent texture (Fig. 2).

(3) Coordinate Correction

The base map downloaded with "Daogle Google Map interceptor" is of longitude and latitude. The coordinates of the picture intercepted with Daogle Google Map and the coordinates of Google Map are completely consistent in the preciseness. Therefore, its preciseness completely relies upon the preciseness of

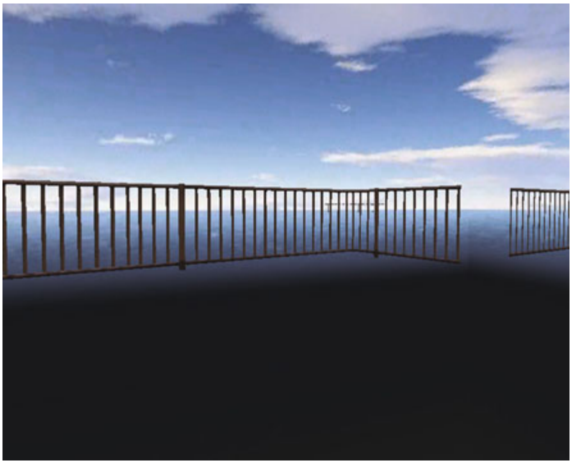

Fig. 2 Design sketch of the fence created with transparent texture

Table 1 Attribute table of line layer

Serial No.	Name	mp Length	mp Layer	Elevation	Color	Line Type
1	Road	676.255354	0	0.01	88	Fold line
15	Trees	589.595777	0	5.00	261	Fold line
18	Architecture	29.911834	0	0.00	432	Fold line
1	Artificial lake	234.35889	0	0.00	261	Smooth line
7	Fencing	1120.3920	0	3.00	585	Fold line
10	Ground track field	116.79024	0	None	733	Fold line

Google Map. Since Google Map has the conditions such as coordinate encryption and bias. Daogle Google Map also has coordinate bias and a little bit deviation. This deviation is basically around 500 m. Therefore, the "base map" will be conducted with grid correction (Table 1), (Fig. 3).

2. Layer Vectorization

The layer of MapGIS is a layer formed from the combination of some related objects by the user in accordance with certain needs or standards. Generally, it is divided into four types of layers, namely, point, line, face, and note. The line layer can also be divided into fencing layer, road layer, tree layer, ground track field layer, etc. As such, in editing the road lines, we can call in the road layer only and shield the layers unrelated with the data of roads, which can greatly reduce the layer data and avoid the interference of unrelated graphics, highlight the parts to be displayed and can also enhance the display speed of the screen (Fig. 4), (Table 2).

In the 3D architecture platform, the roads, sidewalks, trees, and fencing are all established through "line files." Therefore, we put them in the line layer; we put the

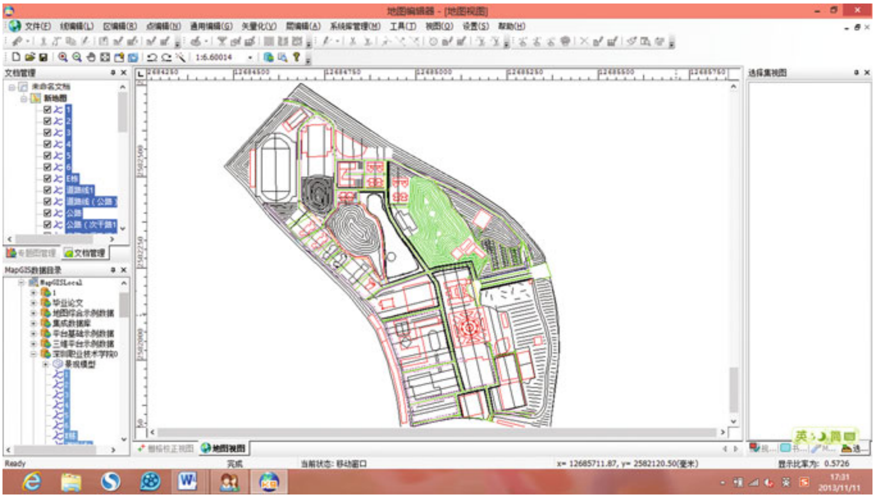

Fig. 3 Line layer

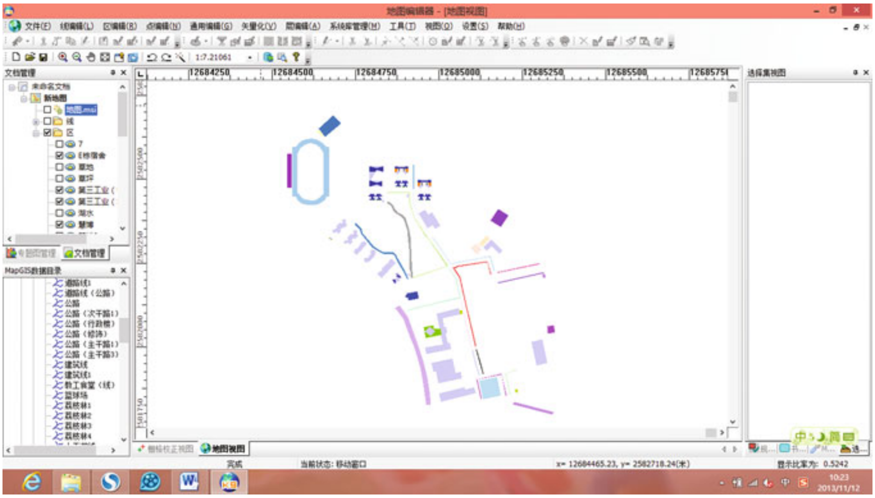

Fig. 4 Area layer

architectures, artificial lake and ground track field in the line layer, because we can establish the area layer through “creating an area by converting line into arc.”

3. Modeling of Symbol Surface Features

The architectures such as the teaching building, swimming pool, dorm area, South Gate canteen, artificial lake, litchi woods, roads, Dayun square, the No. 1 industrial center, No. 2 industrial center, No. 3 industrial center, and football

Table 2 Attribute table of area layer

Serial no.	Name	mp Area	mp Perimeter	Elevation	Floors	Color	Mode of filling
1	Lawn	707745.45	437.021877	4.98	None	23	Conventional filling
1	Teaching building	3610.5887	51.497148	25.00	8	96	Conventional filling
1	Faculty's canteen	726.63081	116.310591	16	5	17	Conventional filling
1	Lake water	28983.87	694.87902	4.00	None	49	Conventional filling
12	Dorm (window side)	410.3064	205.73745	21.00	7	279	Conventional filling
11	Dorm (wall side)	508.8441	188.58729	21.00	7	18	Conventional filling

field are the principal and basic components of the campus landscape. Their landscape model shows symbol visual effect, while the appearance of the architectures is relatively regular. The adoption of MapGIS K9 modeling has a real and detailed effect.

This paper is based on the projection numbered EPSG:3785 of Google MAP. This kind of projection is similar to the coordinate system of Web Mecator projection. Its major difference from the conventional Mercator projection is the earth is simulated into a globe rather than a spheroid, which is an equal-angle projection. First, vectorize the base map of surface features acquired from Google Earth. After the vectorization is finished, newly build a line layer. Draw the contour of architectures in the vectorized base map. And then convert it into area layer through the "shifting to area by converting line to arc" and set the elevation attribute and name of the layer. And then, open the MapGIS K9 3D platform software, choose the relevant 2D database and newly build a 3D database. In the following, click the (Landscape Modeling Tool), choose to establish the texture architecture, open the architecture layer, and enter the elevation data into the attribute of high floors of the architectures as the stretch field. Before the choice, use the texture created with the texture tool to achieve automatic 3D modeling of the architectures (Figs. 5 and 6).

4. Modeling of Irregular Surface Features

The imitation model of some irregular surface features in the target area such as road lamps, stools, steles, sculptures, architectures with an arch top and fitness equipment can greatly enhance and enrich the sense of reality and layer of the true 3D visualized campus scene; the 3DMAX software can create very delicate

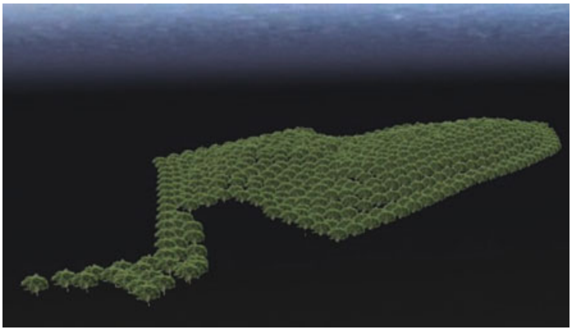

Fig. 5 Sketch of trees

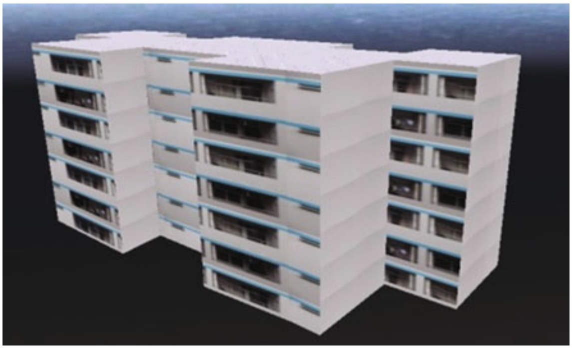

Fig. 6 Sketch of architectures

surface features. Therefore, this part will adopt 3DMAX for the modeling. In MapGIS K9, we can import the external 3D model in the format of 3DStudio MAX (*.3ds). However, what is worth attention is the 3D model might be inconsistent with the actual surface features in the direction and size. After downloading, we need to make some adjustment (Figs. 7 and 8).

Taking the badminton gym as an example, its top and facade are arc, which cannot be modeled with MapGIS K9, but only can be modeled with 3DMAX. The model is then imported into the MapGIS K9 3D platform (Figs. 9 and 10).

5. Modeling of Surface Features on 3D Terrain

The research object of this paper is the campus. To truly and objectively reflect the true 3D virtual campus and achieve the function of spatial analysis, we need to overlay the 3D surface features on the basis of elevation model (DEM). For example, in studying how to establish trees on the DEM surface, first we should use the isoheight elevation data Hi of the Google Earth topographic map intercepted with the Daogle interceptor, the measured average height of litchi trees is Li, the isoheight elevation data of the slopes is Zi = Hi–Li. Since the same isoheight line is

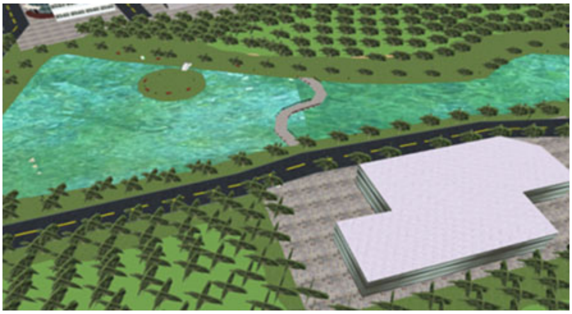

Fig. 7 Sketch of flowing lake water

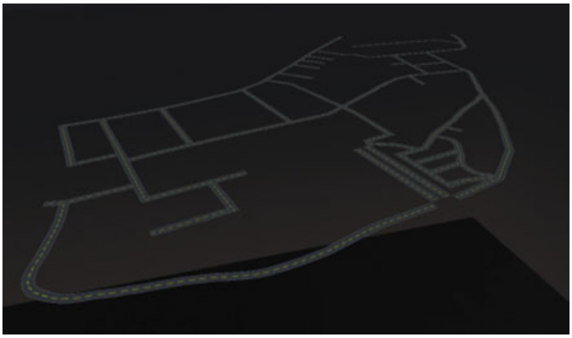

Fig. 8 Sketch of roads

consistent theoretically, we can use an elevation value to express it. Z value is as Formula (1). And through "gridding of discrete data," we will acquire the DEM of the slopes (Table 3).

$$Z = \frac{1}{n}\sum_{i=1}^{n} Z_i \quad (1)$$

And then, we will establish the trees based on the DEM surface, as shown in Fig. 11.

By comparing Figs. 11 and 12, we can find:

Therefore, in establishing trees on DEM surface, we should establish different "line layers" targeting different isoheight lines, and then endow each layer with different elevation values. Meanwhile, the difference distance of trees should also be changed too.

6. Integrated Display of Campus Scene

(1) Integration of architecture models.

It is relatively easy to establish 3D architecture models with MapGIS, but there are many limitations. For example, the flashing board in front of the teaching building, it has a hollowed out design at the surface, which cannot be established

Fig. 9 Sketch of the facade

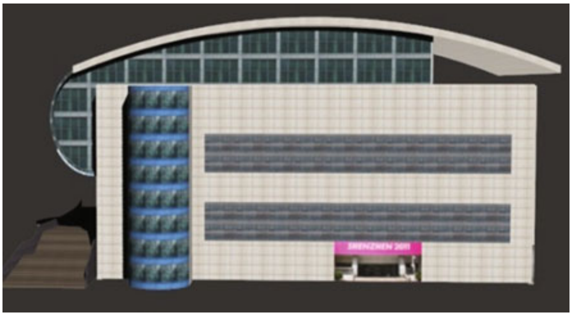

Fig. 10 Sketch of the right side

Table 3 Comparison of Attributes

	Trees at the surface of DEM	Trees at the ground surface
Difference distance	Different	Same
Elevation	Different	Same
Height	Same	Same
Width	Same	Same

with MapGIS. Therefore, this part needs to be established with 3DMAX. If the whole architecture model is established with 3DMAX software, the process will be relatively complex. Therefore, finally we use the two kinds of software in combination to establish the architecture model of "teaching building."

The key step is keyboard positioning. Open the "keyboard positioning" in MapGIS K9, add the 3DMAX file, and find the longitude and latitude coordinates of the surface feature to be entered on the vector picture and enter it, set the zoom ratio, thereby making the two architecture models with the same scale and coordinate and integrated with each other.

As shown in Fig. 13, the major architecture of teaching building establishes the model with MapGIS, because the architecture structure is relatively simple; the part indicated with red box will establish the model with 3DMAX software, for the

Fig. 11 Trees at the surface of DEM

Fig. 12 Trees at the ground surface

architecture structure of this part is relatively complex, with hollowed out and round column design at the middle.

(2) Scene Integration

The main body of the visualized campus to be produced with MapGIS K9 3D platform includes various architecture models, 3D topography, lakes, and trees, and so on. And then integrate the irregular shape model produced with 3DMAX into the main body of the visualized campus produced with MapGIS K9 3D platform, which can bring into a full play the advantages of two kinds of software, thereby making the true 3D visualized campus more vivid and delicate. The key for integration lies in confirming the right size of 3DMAX model in accordance with MapGIS K9 3D model to correctly position the geographic coordinates of the area

Fig. 13 Integration sketch of 3DMAX architectures and MapGIS K9

Fig. 14 Overall bird's eye view

to be integrated, thereby making the 3DMAX model to find out the position quickly on the map. The sketch after the integration is shown as Fig. 14.

Spatial Analysis of True 3D Visualized Campus

Actually the true 3D GIS pays most attention to two key points. One is the model expression of true 3D space, the other is the spatial analysis and inquiry of true 3D GIS. MapGIS K9 provides rich spatial analysis and inquiry functions for true 3D GIS, such as single-point topography parameter inquiry, slope analysis, slope aspect analysis, topography surface distance measurement, two-point inter-visibility judgment, flood inundation demonstration, analysis of visual field, calculation of filling and excavation, topography sectioning and sunlight analysis. As shown in Fig. 15, the length of roads in the campus in the true 3D scene is measured. As shown in Fig. 16 is the attribute inquiry of the architectures in the true 3D scene.

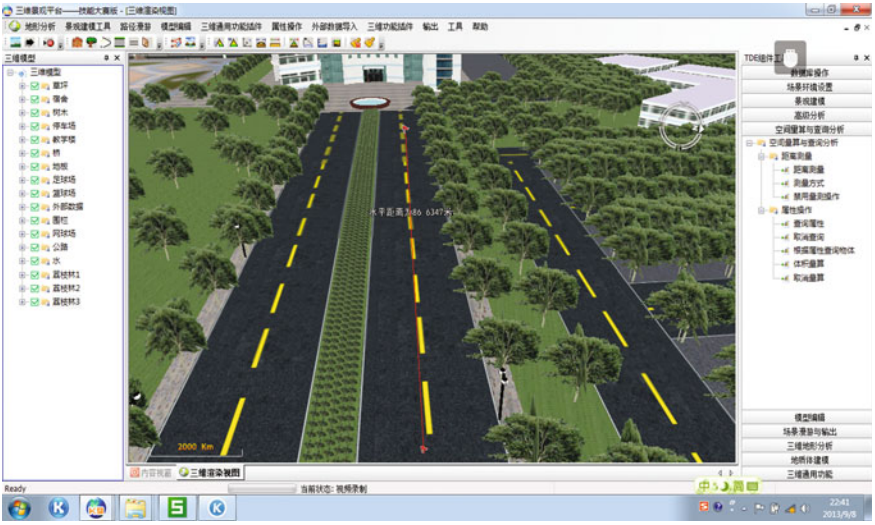

Fig. 15 Measurement of ground surface distance

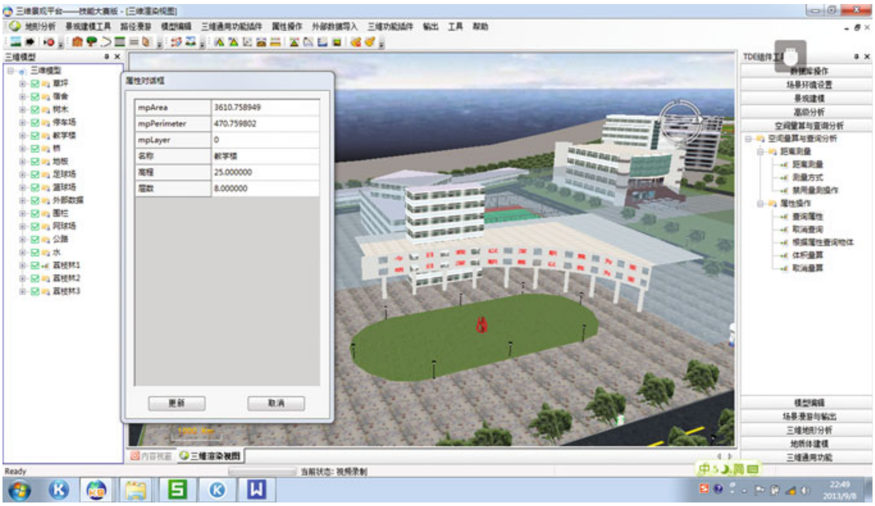

Fig. 16 Attribute inquiry of the architectures

Roaming in the True 3D Visualized Campus

The roaming in the true 3D visualized campus means that the user can observe any surface feature in the space from any direction in the life-like true 3D visual virtual environment and get a feeling as if personally on the scene. In the true 3D visualized campus, the roaming can be fulfilled with a 3D platform software. Open the 3D database, choose the path roaming tool, and open the interface of path edition. Edit the path in the 3D map, and then preview the path, and then choose the video record in the output tool and finally save the video.

Conclusion

The true 3D visualized campus is a part of constructing the digital city. Constructing a true 3D visualized campus is an experiment for true 3D digital urban construction. This paper takes Xili Lake Campus of Shenzhen Polytechnic as an example, targets the common problems of 3D geometric data such as heavy workload and high modeling costs, analyzes and studies the 2D information and topography information of Google Map acquired with Daogle interceptor and greatly reduces the workload for acquiring the 3D data; uses the MapGIS K9 software to establish a basic 3D scene and finish the integration with the models produced with 3DMAX software, which can effectively reduce the modeling cost; finally it conducts spatial analysis and inquiry on the true 3D visualized campus and achieves the roaming in the true 3D visualized scene. The true 3D visualized campus established with this method features a low cost, a high efficiency, and a good effect.

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References

1. Wu, L., W. Shi, and C. Gold. 2003. Spatial modeling technology in 3D GIS and 3D GMS. *Geography and Geographic Information Science* 19 (1): 5–11.
2. He, J., B. Zhang, and Z. Sun. 2013. Production and release of virtual scene based on GIS. *Science of Surveying and Mapping* 38 (4): 172–174.
3. Google Earth Image Download Software–Daogle Google Map Interceptor-V1.1-eiafans Software and Tool Communication Area http://www.eiafans.com/forum.php?mod=viewthread&tid=333462.
4. Xia Chunlin, Wang Jiaqi. 2011. Overview on architecture 3D modeling technology in 3DGIS. *Science of Surveying and Mapping* 36(1): 70–72.

5. Lu, Y., M. Di Xu, and X. Zhang. 2012. Design and realization of 3D virtual campus based on GIS. *Academic Journal of Nanjing Institute of Technology* 4 (1): 81–86.
6. Mu, Y., J. Liu, and Y. Zhang. 2012. Design and realization of 3D campus system based on ArcGIS engine. *Aeronautical Computing Technology* 39 (6): 100–104.
7. Wu, Y., Z. Hu, Y. Huang, L. Lin, and J. Wang. 2010. Design and realization of 3D virtual campus of xuzhou normal university. *Academic Journal of Xuzhou Normal University (Edition of Natural Science)* 28 (1): 75–78.
8. Xu, H., X. Fan, J. Ren, and Z. Zhang. 2010. Urban 3D visualization research based on SketchUp and ArcGIS. *Bulletin of Surveying and Mapping* 3: 52–54.
9. Tang, Z., X. Zhang, and Cao Kaibin. 2010. Research on the application of 3D technology based on skyline in urban planning. *Bulletin of Surveying and Mapping* 5: 10–12.
10. Wang, A., and J. Zhang. 2012. Matching method for physical model and topographic model of 3D GIS architectures and roads. *Bulletin of Surveying and Mapping* 6: 84–89.

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