Design and Implementation of Three-Dimensional Digital Campus Based on Sketchup and ArcGIS

Zitao Du[1,2], Yang Xu[1,2], Hongjie Wei[1,2] and Chaoran Wang[3]

[1] College of Civil Engineering, Hebei University of Technology, Tianjin, 300401, China
[2] Civil Engineering Technology Research Center of Hebei Province, Tianjin, 300401, China
[3] School of Architecture & Art Design of Hebei University of Technology, Tianjin, 300401, China
dzt@irsa.ac.cn, xydf_1992@126.com

Abstract - With the mature of three-dimensional GIS technology, digital campus is gaining more and more attention as micro-reflection of digital earth. As current two-dimensional GIS has some limitations and much three-dimensional information cannot be fully utilized, with Sketchup three-dimensional modeling and ArcGIS three-dimensional analysis model as the base, we designed and realized digital campus of Hebei University of Technology from topographic map surveying, remote sensing map acquisition, geodatabases building, DEM production, main body construction modeling, and later function realization. This study provides new idea for campus planning, digital management and emergency solution.

Index Terms - three dimensional digital campus, ArcGIS, Sketchup, DEM, GeoDatabase

1. Introduction

With the development of informationization, digital campus construction became one indispensable part of campus construction. Campus digitalization can be used to achieve effective management of campus facilities and rational allocation of resources. Nowadays many colleges campus management system based on GIS is two-dimensional, which is a two-dimensional projection of real-world. As a result, it has a serious limitation that a lot of three-dimensional information can't be fully utilized. Compared with 2D GIS, 3D GIS can be more intuitive and more vivid in displaying the real world [1]. 3D digital campus system can not only give people an immersive experience, but also provide a new platform for campus planning, digital management and emergency solution.

2. Study Area and System Introduction

This research focuses on the Beichen district of Hebei University of Technology, Tianjin. The campus covers a total area of 2km^2, with nearly 550,000 m^2 building completed and put into use and another 480,000 m^2 building under planning. 3D digital campus construction can provide the most realistic and intuitive technical support for campus planning and building, effective management of campus facilities and rational allocation of resources, the use of three-dimensional landscape of web publishing, and can greatly facilitate the school's display of publicity work.

ArcGIS10.1 is a geographic information system produced by Environmental Systems Research Institute Corporation, United States. The ArcGIS 3D Analyst extension provides tools for creating, visualizing, and analyzing GIS data in a three-dimensional (3D) context. ArcGlobe10.1 and ArcScene10.1 is one part of ArcGIS 3D Analyst extension. ArcGlobe is suitable for a wide range of city-level three-dimensional digitalization, while ArcScene is more suitable for small scale high quality modeling and rendering [2-3].

Google Sketchup is a 3D modeling program owned by Trimble Navigation, Ltd. It is very easy to use, and its data format is fully compatible with ArcGIS10.1. So with ArcGIS10.1 as the platform, our study uses Google Sketchup8 in refinement modeling.

3. Technical Process of 3D digital campus construction

In this study, the 3D Analyst module of ArcGIS10.1 is used as the basis for the construction of three-dimensional digital campus. (1)Do campus vectorization through topographic surveying, DOM acquisition, and geographic data collection. (2) Choose proper type of geodatabase: File Geodatabase has no capacity limitation of 2GB, and is more suitable for larger scale of geographical information storage and management. As a result, our study chooses to use File Geodatabase. Then, we will design attribute table, add files and use Field Calculator for assignment. (3) Google Sketchup is used for main buildings refinement modeling. (4) Export, positioning, add attributes and Symbology in ArcScene10.1. Technical flow chart as Figure 1.

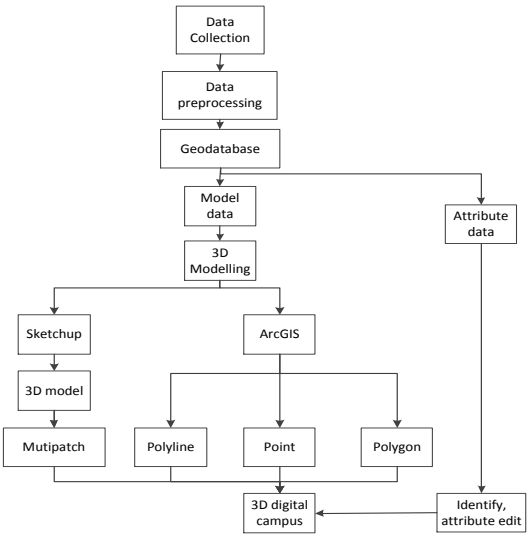

Fig. 1 Technical Flow Chart .

A. Data collection

1:500 topographic map surveying is first performed to collect CAD maps for other campus facilities. (1) Collect the data of the zone, design the program of the control network and measurement. (2) Use GPS to position some control points, use total station to infill the control points of the zone, according to the principle of "control and then partial" in measurement, In addition, we need other mapping information, such as the feature name, the model of the zone partial, etc. which should be represented by geographic codes. (3) Refer to the sketches and photographs of the area. Use SOUTH CASS 9.0 to draw the map.

Then, obtain the 0.61m QuickBird high resolution remote sensing image of Beichen district in May 2012, do the geometric correction, mosaic, and enhancement to enhance the image.

Finally, use digital camera to capture images of each building facade, using Photoshop for distortion correction and cropping to produce architectural textures. Collect the name and description of the plans of all the schools, establishing property attribute tables.

B. Geospatial database creation:

GIS spatial data currently is not standardized, and three-dimensional digital campus has too much variety of data sources, so a unified multi-source spatial data in a spatial coordinate system will become a key of geographic database construction.

First, check the geographic data quality and do the projection transformation. Import the 1:500 topographic map as a base map, turn the DWG file into Polyline Feature Class, in ArcScene checks on topographic map, and in ArcMap remove miscellaneous extra line to ensure the vector data is correct. As topographic map uses the WGS-84 geographic coordinate system, in ArcScene, we should use a projected coordinate system, and therefore properly conduct in ArcScene three-dimensional display and projection transformation must be carried out to improve performance. Tianjin is located in the vicinity of 117 ° east longitude, so choose WGS_84_UTM 50N projected coordinate system. CAD drawings and other pieces of the corresponding data should also be checked and modified. Remote sensing image projection is Popular_Visualisation_CRS_Mercator, we also use ArcGIS Project Raster tool to project transformation.

Then, georeference of raster data and the 1:500 topographic map is performed. Select a number of points on the remote sensing image and topographic map, update display, save the georeferenced remote sensing image. CAD maps to the data format conversion, according to the actual situation is converted to the corresponding points, lines, polygons, and doing editing operations such as spatial correction on the Feature Class to ensure the geodatabase data quality.

At last, refer to the national fundamental geographic information standards and relational data theory, combined with the actual situation in campus, design the file geodatabase feature class attribute table, which attributes to the data storage, and must meet the following conditions:

(1) Each attribute value in the form should be the basic unit, which can not be separated any more.
(2) The name of each column should be exclusive.
(3) Each column in the table must have the same data type
(4) The form should never have the lines which are same as others.

The attribute table we designed is just like the Table 1

TABLE I Attribute table

Field name	Field type	Field length	Notes
OBJECTID*	OBJECTID	-	
NAME	TEXT	30	Building name
NO	TEXT	10	Building No.
District	TEXT	30	District name
Describe	TEXT	200	Describe notes
Elevation	Double	-	Land elevation
Height	Double	-	Building height
Orientations	TEXT	10	Feature Orientation
Styles	Short Integer	-	Feature Style

C. Data check:

Check each feature of the Table. Add the appropriate fields, delete the redundant fields in accordance with data dictionary. Fill the attribute column using the field calculator. Topology checks, establish Feature Dataset, import the polygon feature, establish topology rule as per "no gaps" rule. If an element has topological errors, ArcGIS will mark it red, then we can use the Editor toolbar in ArcMap to edit feature class and eliminate topological errors. The data after checking is shown in Figure 2.

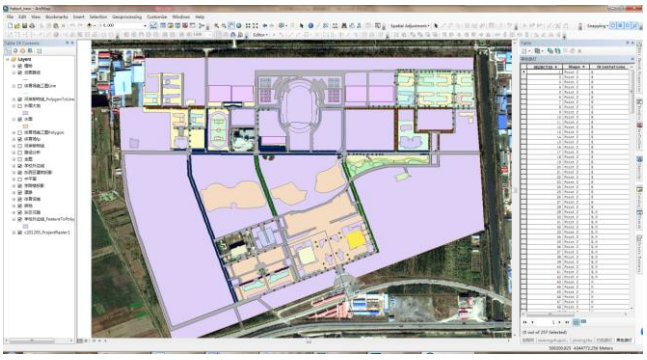

Fig. 2 Vector map made by ArcMap.

D. Three-dimensional modeling and the main building orientation:

Paint the 1:500 topographic maps, floor plans and elevations according to the field work and the surveying and mapping industry standard of People's Republic of China: three-dimensional geographic information model data product

specification CH-T9015-2012, I -class standards for school-wide three-dimensional modelling. Plane precision 0.2m, model requires modelling objects should reflect any detail changes of dimension bigger than 0.5m, such as roofs, building body, parapet, etc. The base of building models should be at the same level terrain position, consistent with the undulating terrain. The error of the model height and the actual object height should not exceed 1m.

For school building, laboratory building and other main buildings should be performed in Sketchup modelling in detail: Generate the main building shapes, including spherical to the body, arc and other geometric shapes which are more complex, This requires the performance of the main body of the building geometry . Digital cameras capture images decoration the facade as a building material for the real texture mapping process model uses texture material should be consistent with the exterior of the building to reflect the architecture of the real texture and detail. Note that the texture should not contain objects other than the object modelling, photographs and maps in the acquisition process, when it should be noted. ArcGIS can directly read the plane photo mapping, modelling for architectural surfaces need to fold it into a face, or use the system comes textures, homemade photo-textured surface textures loss will occur the phenomenon. Modelling attention during the quality control model, modelling during the design of the architecture and art college students for the quality supervision and inspection as well as the model landscaping. The accuracy of the model were painted outside the industry tune the model size and the actual measured size and design dimensions are compared.

E. The set-up of DEM

The Beichen campus of Hebei University of Technology is located in the Beichen district of Tianjin. It has a flat terrain on an early alluvial plain. The GPS measurement of Beichen district shows that its geodetic height is about 5m high, with little terrain difference. Therefore, we choose the right lakes, gardens and other regions to establish local digital elevation model (DEM).

Conventional DEM data models are mainly based on a regular Grid DEM and triangulated irregular network-based DEM, known as "TIN". But Grid DEM terrain has difficulty in precisely describing the structure and mutations terrain. TIN display does not have a smooth display, and has a complicated storage and operation, making it more difficult to use. Therefore, we select the feature embedded digital elevation model (features preserved-DEM, F-DEM), the morphological description of the terrain of significance points, lines (points, lines and areas, PLA) embedded grid DEM structure, can fully describe the structure and mutations terrain topography, but also safeguard the DEM terrain Representation and processing efficient, simple advantage[4].

This paper uses ANUDEM 5.3 integrated into ArcGIS10.1 to create DEM. Mainly using the TopoContour defined list of line feature class representation and identify its elevation contour fields and TopoPointElevation defined point feature class list, which means that the surface elevation and point feature that identifies its elevation value fields.

Using 1:500 topographic maps, reserve the roads, bridges, view platforms, rivers and lakes and other surface characteristics of surface features, remove housing and others which are not affixed to the ground vegetation and other surface features, the use of line elements elevation fields and discrete elevation points established DEM, according to the actual situation of the main input feature data elevation data type, this case is due to the production of local DEM smaller range, there are certain limits restrictions, select CONTOUR data types, namely the main types of input data such as elevation value line. There is no check in ArcScene flying spot, and if so, edit the turning point elevation contour lines to regenerate DEM. After the examination, turn the Grid DEM into a three-dimensional vector for data by Interpolate Shape tool. Then check and adjust the appropriate changes. Use three-dimensional display of class symbols. Symbols of the garden after the eastern part of DEM is shown in Figure 3.

Fig3. Symbology of East District

4. Function Realization

A. Roaming Animation Rendering

Create a line feature as the path of 3D fly route, and select all the routes. Open the Animation toolbar, create flyby from path, set vertical offset (usually 2m is okay), then import animation, open animation control tool, preview the animation, if you are satisfied, export animation, add background music and effects in Adobe Premiere, a wonderful 3D tourism animation is done.

B. ArcGIS Engine based function development

Save the Digital Hebut.sxd file in ArcScene. Create a new Windows Form Application in Microsoft Visual Stdio2010 using C#. Add TOCControl, ToolbarControl, SceneControl, LicenseControl. Among them, the License Control is more important, it provides a series authorizations for ArcGIS Engine [5]. It will cause some controls unavailable. Write codes on demand, Debug result is as follows:

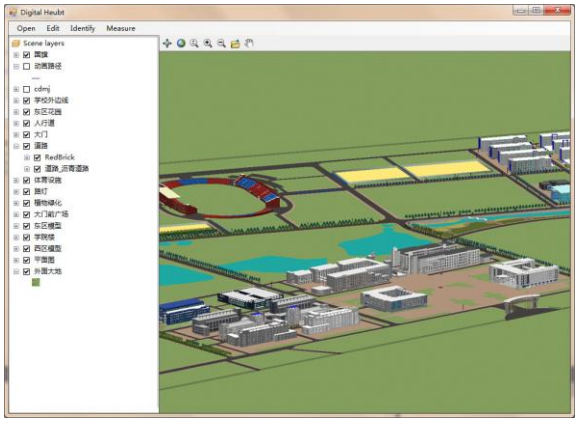

Fig4. Digital Hebut campus after ArcGIS running

The program based on ArcGIS Engine needs the support and license of ArcGIS Engine Runtime. Then the program is set up.

5. Results

This paper gives a systematic description of ArcGIS-based three-dimensional digital campus design and achievement methods. It reproduces a truly interactive campus scene, and also has a certain attribute query and analysis functions. Therefore, it will change the traditional form of campus plan, promotion display and facilities management. It will greatly promote the development of school-related disciplines, improve campus planning and construction. With the help of ArcGIS spatial analyst, it will be much easier for students to look for available classrooms. It also provides a new technological platform for emergency evacuation. Digital campus is one part of smart city, the research on digital campus also has important reference significance for large scale digital construction.

References

[1] GangLee, FuzhenLiu, ZitaoDu. Engineering survey. Chemical Industry Press.2011,3
[2] GuoanTang, XinYang. ArcGIS Geographic information system spatial analysis experiment course (Scend Edition). Science Press. 2012
[3] ArcGIS Help10.1 http://resources.arcgis.com/en/
[4] GuoanTang, FayuanLee, XuejunLiu. Digital Elevation Model Course. Science Press. 2010.
[5] Zhang S. Development of virtual Campus System Based on ArcGIS. Physics Procedia, 2012, 33: 1133-1139.