Research on the Application of 3D Dynamic Management System of Airport Earthwork Construction in Mountainous Regions

Bo Li

China Airport Construction Group Corporation, R&D Center

Beijing Super-Creative Technology Co., LTD

Beijing, China

elizabeth0423@163.com,

Junku Xu

China Airport Construction Group Corporation, R&D Center

Beijing Super-Creative Technology Co., LTD,

Beijing, China

13621050874@139.com

Ke Tang

China Airport Construction Group Corporation, R&D Center

Beijing Super-Creative Technology Co., LTD

Beijing, China

157472643@qq.com

Fengchen Chen

China Airport Construction Group Corporation, R&D Center,

Beijing Super-Creative Technology Co., LTD

Beijing, China

cfc_0@sina.com

Abstract—**Due to the characteristics of long period and complicated project, in order to display and manage the airport project in a comprehensive and visual way, it is imperative to establish an application system in 3D airport simulation in advance. This system is just based on this theory and developed by adopting 3DS MAX and Sketchup modeling tool and utilizing OpenGL 3D engine based on the development language Visual C++. The system realizes 3D informationized display and management of airport. The system is testified in necessity and intuitionism through practical examples.**

Keywords-3D; GIS; OpenGL; Airport; Engineering; Simulation

I. INTRODUCTION

Against the backdrop of the rapid economic and social development in China, the airport construction has been increasingly intensified. However, airport engineering is a very complicated project. With long cycle, wide range and complex project, the airport construction in mountainous regions faces ever more prominent high-fill issues with great difficulty in technology and engineering management. The resolution of the aforesaid issues, orderly and efficient implementation of the airport construction in mountainous regions , guarantee of the engineering quality and schedule as well as the fulfillment of the expected goal are regarded as a problem that has plagued the industry for many years. Therefore, new methods are urgently needed to enhance the construction and management level of airport construction and realize the various expected goals.

GIS technology (Geographic Information System, GIS), as the bond that connects computer technology, space technology and modern information technology, plays an increasingly important role in advancing the informatization of the national economy [1]. GIS, as the general term of information system, refers to the scientific management and analysis of the spatial data on the basis of the spatial database under the circumstances of the support of the software and hardware, thus providing the information-based technology system for the planning, decision, management and research of the users [2]; meanwhile, it is also a computer system that collects, processes, stores, inquires, analyzes and displays the data related to the space of the Earth's surface. [3]. The traditional two-dimensional GIS could realize the management of the spatial data but cannot resolve the issue of visualizing the space data [4]. Due to the intuitive feature [5], 3D GIS could clearly express the objective 3D world, thus being widely applied to more and more industries. [6]

Based on the 3D GIS technology, the 3D visualization research on the airport earthwork construction is conducted to explore the related theory and key technology. On the basis of which, the OpenGL 3D engine is utilized to develop a visualized application system, which could provide an efficient method and a realistic platform for the transition between informationalized construction and scientific research achievements.

II. SYSTEM ARCHITECTURE

C/S architecture is adopted in this system. In terms of the dynamic scheduling of data, multi-thread sequence is used to enhance the efficiency of the real-time rendering and drawing. In the loading procedure of browsing, the system mainly uses the detail hierarchical model of LOD to resolve the transition between topography loading speed and visual smoothing. LOD technology could simplify the details of objects according to certain rules and choose the object expression means of different detail degrees in accordance with different needs . [7]

The system database adopts the data center model of the unified data bus, integrates various kinds of data in the data dictionary mode, manages and releases all kinds of data in the form of data bus and supplements mining engine of geographic data according to professional application to realize the comprehensive analysis of the data. Among the system database, ADO technology is applied to the operation of database.

OpenGL (Open Graphics Library) refers to a professional graphic programmatic interface that defines cross-programming language and cross-platform programming interface specification.. As a professional interface of graphic program, it is also a low-level graphic library with strong functions and convenient invoking. With the feature of wide applicability, standardized, stability, expandability, reliability, transportability, scalability, usability and practicability, it could also enrich the documentation [8].

From the perspective of the business logic elements of the system, the system is generally divided into presentation layer that is client application layer, system application layer or function layer, system service layer and data layer that is data storage layer, which are presented in Fig.1:
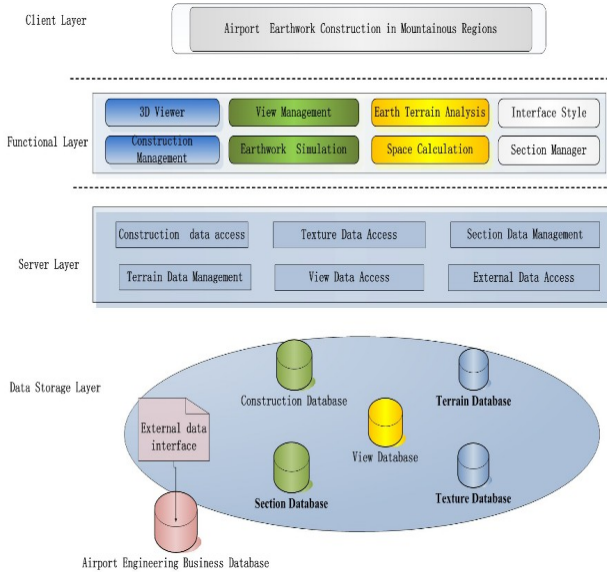

Figure.1　System Architectures

The aforesaid diagram shows that the whole architecture takes service layer as processing engine, function layer as the control core and data layer as the basis and makes use of the various access means on presentation layer, thus entirely providing services to the client application. The architecture also tells that through the processing of the business layer platform, the direct accession browse and the key data resource layer are separated, thus realizing the isolation of data and browse. Only the data processing requests that have got the permission of the business layer could be allowed to

manipulate data in database so as to guarantee the security of the data.

III. SYSTEM FUNCTION MODULE

A. 3D Browse Module.

This module organically combines the terrain for the airport design, original terrain and the terrain of the outlying fields of the airport and affixes them with textures of different colors, which makes it quite easy for comparison. Both of the original terrain before the design and the flat terrain after the design are used within the range of the airport; however, outside the airport, the SRTM DEM terrain data of 90 meters resolution ratio is adopted. Due to the large data volume, the LOD Level of Detail Model is utilized in the system. Pyramid model is established for the mass data and 3D data is quickly and stereo rendered step by step with high efficiency. Besides the navigation panel, shortcut menu could also be conveniently utilized to translate and rotate the 3D scene.

B. Viewpoint Management Module.

In this module, users could save some frequently scenes so as to facilitate the fast positioning in the future. The addition of viewpoint means that users could mark the current coordinate and save the scene if they find anything interesting. Meanwhile, they could also add some attributes, such as time and multimedia data and so on. For example, addition of a viewpoint at the second channel of a certain section could facilitate the quick positioning and make it easier to observe the conditions of the fill. All the viewpoint data are stored in specialized viewpoint database for easy and convenient management.

C. Construction Data Module.

The biggest characteristic of this module (including the corresponding data entry module) is its 3D dynamic demonstration of earthwork construction situations and the construction schedule calculation by combining with the daily construction data, which bears great significance to the management of the construction data. As the wide-ranging earthwork construction is divided into several sections and each section is performed by different construction units, therefore, there is a very large amount of construction data to deal with and the construction schedule of each construction unit is different. In order to manage the construction data better, it is necessary to establish the construction database and input the data according to different construction sections respectively. For each section, the construction unit, the planned general fill, the amount of excavation and accumulated ratio of completion shall be recorded. Meanwhile, the daily amount of evacuation and fill volume as well as the time shall also be written down under the table of each section. All the data stems from the weekly and monthly reports provided by the construction unit of each section. It is the dynamic and real entry and demonstration of the construction data that enable the managers to easily check the earthwork construction schedule.

D. Module of the Earthwork Terrain Analysis.

GIS technology is advantageous in spatial analysis. In comparison with the general 3D demonstration system, the 3D GIS application program generally offers the function of spatial query and analysis. By utilizing 3D technology, this module also provides some other basic functions, including the 3D analysis of the topographic profile, topographic cutting and excavation as well as fill.

E. Spatial Measuring Module.

Earthwork construction usually relates to the issue of spatial measuring. This module also provides some commonly used function of spatial measuring, including the measuring of the 3D space distance, 3D space area and 3D space volume so as to facilitate the users' analysis and check.

F. Earthwork Construction Dynamic Simulation Module.

This module is mainly divided into two parts: one is the earthwork demonstration part and the other is the earthwork dynamic simulation. As for the earthwork demonstration part, the users include the airport managers who could choose to browse the original terrain and the design terrain. While browsing the design terrain, one could choose the overall planning progress, i.e. all flat terrain, detailed planning progress, i.e. topographical condition of the current time planning as well as the actual construction condition, i.e. the actual topographical condition calculated on the basis of the earthwork construction data. Meanwhile, for convenient management, each two of these terrains can be superimposed for comparison. While comparing the actual construction progress with the design terrain and the original terrain, one could find the change of the original terrain at the current time point, how much the excavation and fill left as well as the specific position of the excavation and fill. What's more, the users could also control the display of the section boundary, deployment boundary as well as the section and fill ditch for macroscopic browsing.

The dynamic simulation of the earthwork project provides a dynamic change process of the terrain, which could simulate according to construction demonstration period chosen by the users and the simulation intervals such as every three days, five days or a month. However, during the earthwork construction, the dynamic change process from the original terrain data to the terrain data of the current construction period in accordance with the input earthwork construction data; even the formed land of the airport could be simulated after the completion of the earthwork construction.

To better observing whether the earthwork construction is excavation or fill, two colors are used in the system to dynamically explain the location of excavation and fill. The overlapping contrast between the design terrain and the original terrain is presented in Fig.2.
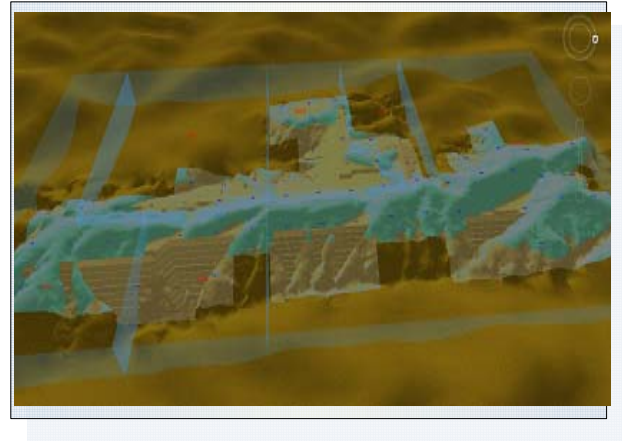

Figure.2   The Overlapping Contrast between Design Terrain and Original Terrain.

G. Section Independent Management Module.

This module targets at independently observing the conditions of the excavation and fill of the earthwork of a certain section. According to the data of different stage in the section, the demonstration of the progress of the excavation and fill could be dynamically simulated. Meanwhile, in the process of contrast with the main form, if the main form displays the original terrain of the section, the independent section form could simulate the progress, thus giving striking contrast and leaving direct impression. The observation of the independent section is shown in Fig.3.
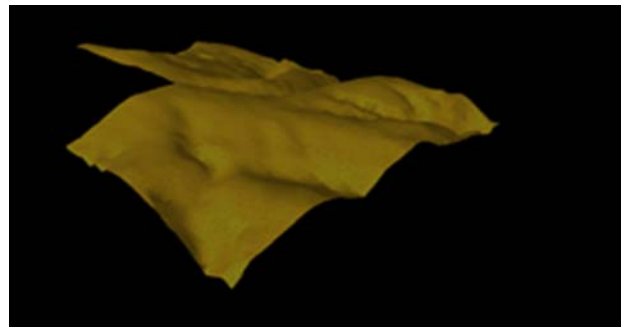

Figure.3   The Observation of the Independent Section

H. The Interface Style Module.

At present, user experience has been attached great importance by the application program of various kinds; many of which offers the customizable user interface to meet the habits of the customers. This module also provides different interface styles for the users to choose according to their own habits. Specifically, different styles such as Windows XP, Windows 7 and Office2010 could all be applied to the interface of the software.

Database Module. The databases that shall be established in this research system include the terrain database, construction database, section database, viewpoint database and texture database in accordance with the principle of consistency, integrity, safety, scalability and standardization.

I. Database Module

The databases that shall be established in this research system include the terrain database, construction database, section database, viewpoint database and texture database. The database construction is in accordance with the principle of consistency, integrity, safety, scalability and standardization. Besides, the operation of the database mainly adopts ADO technology.

IV. SUMMARY

These systems adopts the 3D GIS technology on the basis of integrating the various business data, airport terrain data and the earthwork construction data of the airport and realize 3D visualization of the earthwork construction of the airport for the purpose of facilitating the comprehensive management of the airport. It not only enables the managers of the airport to browse, check and analyze the construction progress, but also provides support for the scientific decision-making and efficient management.

By now, this system has been applied to Shanxi Lvliang Airport, a typical airport in mountainous region with undulating terrain, complicated geological conditions, large amount of excavation and fill as well as vulnerability to construction conditions and precipitation event. Due to the good effect during the trial stage, it has received the consistent praise from the owners. On this 3D dynamic system platform, the data that is of great concern to many different departments could be inserted, thus fundamentally realizing the sharing and integration of the resource and information; meanwhile, it could also provide dynamic, real-time, direct and comprehensive management and decision-making support for the construction of the airport

and lay a solid foundation for the efficient operation of the airport in the future.

However, as a comprehensive system, it still faces some period problems of the designing and development. The various departments shall consider how to cooperate on the large amount of earthwork data provided by many construction units. In this regard, the system is still far from perfect in terms of design. Therefore, the system shall be further perfected with the structural design of the data improved. In the next step, the achievement of this system will be applied to airports of which are under construction or completed in mountainous regions so as to fulfill the goal of improving this system while catering to the management of the construction of the airports.

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