3-Dimensional Terrain Fly-through Simulation In Large-scale GIS

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Abstract
In Large-scale GIS, 3-dimensional terrain visualization not only have characteristics of all ordinarily 3D terrain viewing, it also has compact relationship with the data structure of the system. The realization of 3D terrain viewing is based on the dynamic management of data. In this paper, the Characteristics of data, organization and management of data, terrain generalization in 3-dimensional terrain fly-through simulation in large-scale GIS are discussed.
Key words
3-dimensional terrain, fly-through simulation, dynamic management of data

1. Introduction
Thousands of years ago, human being understand the world around us by means of map. By computer technology, GIS turned the traditional map into electronic media and it give a great, flexibility for human being to use the map. But visualization of GIS information is mostly in 2D method, with the development of computer and other relative technology, the visualization of 3D terrain gradually become reality.

Based on “digital earth”, large scale GIS has many characteristics such as multi-resolution, multi-scale and contains great volume compared with general GIS. Its organization and management of spatial data have some characteristics.3D terrain visualization, based on DEM in GIS, reveal DEM 3D figures to user by computer’s calculation. The process of 3D terrain fly-through is shown by the 3D figures on the way dynamically along the defined path. In that process, issues such as map combination, handling of data in different projection zone, which is unavoidable, are discussed in this paper.

2. data basis

2.1 organization of DEM data in large scale GIS
When DEM is stored in geographic coordinate (longitude and latitude), there are the same rows and columns in each map sheet. It is represented as a rectangle. But when DEM is stored in Descartes coordinate, the data in one map sheet is represented as an approximately trapezia. Some difficulties will occur when combining adjacent map sheet. To solve this problem, we generally cut data with the exterior rectangle of map sheet to form a rectangle. Another question is that different map sheet has different data amount (different rectangle size), it induces the problem of data combination in data roaming across map sheet. Our solution is to reorganize the data to make

them as the same size. The principle of data organization is as follows:

(1) Reorganizing all of data under the spatial coordinate frame work of "digital earth".

(2) Each data file has same size no matter what its scale.

(3) Based on resolution.

(4) Creating data file of description information, which include resolution, projection zone, coordinate etc.

2.2 Spatial data management

2.2.1Management and seamless linkage great capacity data

In fact, Management of great capacity data means data management of viewing area range (working area). Seamless linkage is a concept based on interface of user and data. It is result of spatial data integration in spatial data base. Access of spatial data can be realized transparently in user interface according to coordinate, thereby form integrated information of seamless linkage in geographic space. Based on the principle of data organization mentioned above, system can break the restricting of map sheet by user's requirement and realize seamless linkage of data. In practice, the spatial coordinate is used as basic connection unit, in the system, the viewing area is associated with relevant data in the area through spatial coordinate. When user roam to some area, the system get correct data file of all related map sheets according to coordinate of viewing area.

Seamless linkage of spatial data includes several issues: projection, coordinate system, scale, accuracy, etc. The same projection and coordinate system are adopted for various data sources. Then geographic information can be seamless linked for integration data roaming and information query can be realized. To unify data management and data matching, a series of description information must be recorded. These information mainly includes map projection, data range, coordinate and data path.

2.2.2Resolution based on map projection

The data has different map projection because of different map scale. In the process of dynamic management of middle and large scale data, a unavoidable question is cranny of projection zone. For example, for China, when map scale less then 1:1,000,000, we usually use minimum error equidistant conical projection with two standard parallels (Kavraisky IV), it don't have problem across different projection zone. But when map scale greater then 1:250,000, we generally use Gauss projection, so that we must face to the problem across different projection zone when data is roamed in large data range. Because of our reality world is a continuous geographic space, the system must to be adjusted to get an effect of continuous space to user. We have two methods to resolve problem across projection zone :

(1)Geometry transformation: when viewing area locates in same projection zone, data in this rang link naturally by there coordinate. When viewing area locates in different projection zone, geometry transformation must be employed. The processes are as follows:

a. Transform data from different projection zone to the same projection zone (such as transforming right zone coordinate to left zone coordinate).
b. Move data of right zone to left zone, each of them rotate clockwise or anti-clockwise.
c. Resample the grid data to generate new data set.

(2) Projecting transformation in real-time: DEM is stored in geographic coordinate. Center meridian is always in the center of the viewing area when display. In data roaming, data in viewing area is projected to the same coordinate system in real-time. In this process, data link each other in real-time to avoid the problem of cranny across projection zones.

3. Dynamic management of data in 3D fly-through simulation

General method of 3-dimensional terrain fly-through simulation is terrain real-time generating technology based on DEM. Because of the hugeness of terrain data, it brings out the high request about computer hardware to achieve real-time display, especially in fly-through simulation of great capacity data. Availability doable method is to reduce data amount in display. We accomplish this goal according to the principal of correlation of visual field. It takes the reference jumping-off point by the projection on to horizontal of viewing point. Based on it, a data set can be generated to perform 3D display. With the moving of viewing point, the content of data set come to changing ceaselessly, so fly-through simulation is realized. In this process, kernel content is dynamic management of data.

Our manner of dynamic management of data is to build two buffers, exchange content of two buffers ceaselessly in the viewing process. These two buffers, what we called are view buffer and data buffer. View buffer contains the data that is shown in the screen and data size is comparatively small. Data buffer contains the data of working area. Generally, data buffer greater then the view buffer. The function of working buffer is to let data pass in and out by requisition of display, avoiding view buffer read data file frequently. The relationship between data, view buffer, data buffer and 3D scene is shown in figure 1, the process of data dynamic management is shown in figure 2.

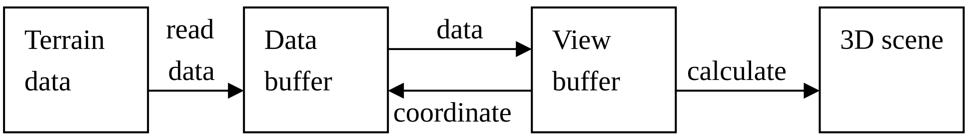

figure 1

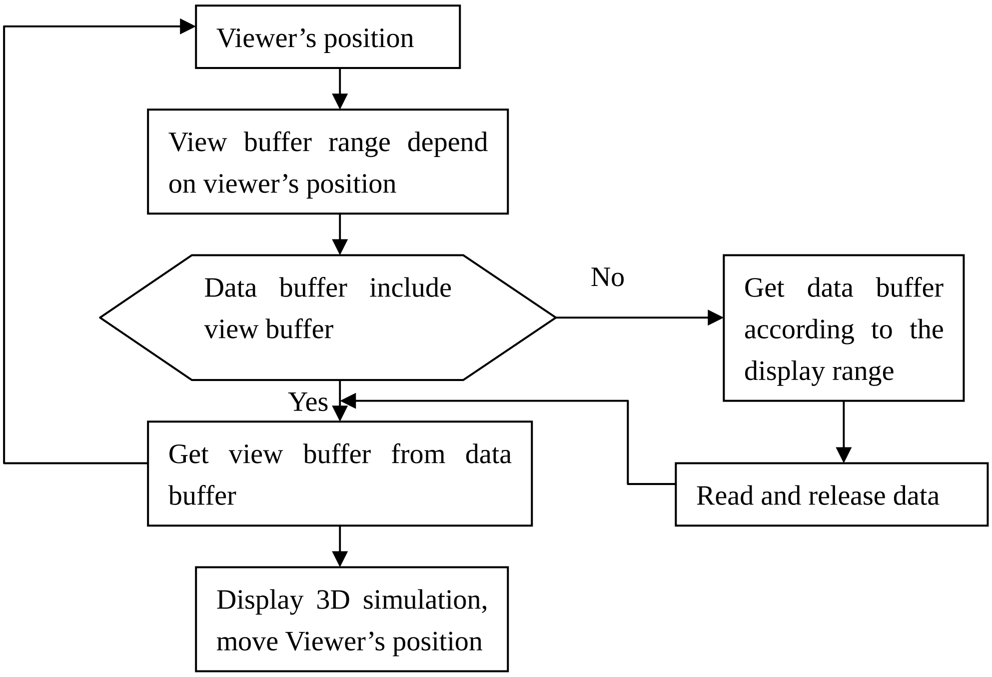

Figure 2

There are many ways to create data buffer. Common way is to divide data into many data blocks which are the basic unit of file to read. To improve the reality of 3D showing, texture mapping is often used. The texture images include airphoto and satellite image. Texture images, like DEM data, also raise issues of data dynamic management. They have the same processes and coordination system with DEM data. Ordinarily resolution of texture image greater than DEM will achieve good view effect. There is no much influence of flying speed when the difference of resolution between DEM and texture image is not too much. But when the difference of resolution is great, resampling of texture image will greatly slow the speed of flying simulation.

4. Realization of 3D viewing

4.1 Building of multi-resolution data for display

DEM data usually contains large amount data and this will reduce the speed of 3D display. By use of multi-resolution data model, we can improve display speed efficiency. An ideal model should has a result as follows: it has more detail close to the viewer's position to bring out realistic effect and has a rude frame far away only to be used as background. If we create a different detail model according to the distance from the viewer's position, we can reduce the amount of calculation and improve the capability of display. We would make viewer's position as jumping-off point, divide data range into several area according to the distance to the viewer's position, expend the triangular network along the viewer's direction. Details of terrain data are in proportional to the distance to the viewer's position. More closer to the viewer's position, more thicker the triangular network and more detail. This model is greatly reduces the computer calculation in 3D display and improves the speed. At the same time, it can solve the problem about continuation of space of terrain surface and time.

4.2 Reality of terrain

Reality is the important part of 3D terrain display. With the advance of computer software and hardware, the request to improve the 3D terrain display has gradually heightened. To improve the reality of terrain display, we usually overlay texture image and reality object (like roads, river, buildings, etc.) with terrain. In some GIS, for the function of query and management of spatial information, it is needed to build 3D objects model like roads, rivers, buildings to create spatial 3D body.

5. Applications

Working for many years, research center of government GIS national bureau of surveying and mapping has developed a software platform. Which has unique characteristics that aim at "digital earth" in data management. Based on this management, we have finished our 3D terrain fly-through simulation system. The organization of data is as follows:

(1) Each data file has same amount.
(2) In middle and large scale, data organize by project zone.
(3) Row is originated from equator.
(4) Different file postfix represents different data content.
(5) Basic information of each file (resolution, number of projection zone, number of row and column) is implicated in file name.

According to the requirement of fly-through simulation, some description information has been added, which includes data projection, data path, resolution of DEM and image.

Functions of system include:

(1) 3D DEM scene display and fly-through along given path of single data file.

(2) 3D DEM scene display and fly-through of multi-data file with large range and across different projection zone.
(3) 3D scene display switch from grid model, color model and texture model.
(4) Real time change of vertical scale.
(5) Rotation 3D objects real time by mouse and keyboard.
(6) Real time query of elevation and coordinate of DEM by moving mouse.
(7) The speed of flying can be control by user.

In dynamic management of data, data file is treated as basic block of data buffer. View buffer takes the data range depended on the viewer’s position. The system can manage the situation across different projection zone by the method of geometry transformation. The advantage of this method is that it can organize data quickly if you ignore the short period pause when data across two projection zones. Otherwise, the system can automatically change the data range of DEM and image according to difference of their resolution. When resolution difference between image and DEM is too great, the system will adjust the DEM data range to assure the speed of display.

6. Conclusion

Being an important part of geographic information visualization, display and fly-through simulation of DEM in large scale GIS has widely application potential. We make some test and solve the problem in management of great capacity of data and data across projection zone. In the future, we will make our effort to improve the functions. Such as management of data, optimizing algorithm to use memory efficiently, enhance reality of display.

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