Development of 3-Dimensional Geographic Information Systems Software


Abstract

A high-performance, component based 3-Dimensional GIS software was developed in this project. Though it ran only on a desktop environment, it could be extended to network environment using component object model technique. In this project, I developed a high performance geometric modeling and visualization system that was integrated to an internal GIS engine. Since the visualization structure is designed by following scene description method, it supports easy access to build and extend to complex scene. As a joint project, we also developed terrain analysis system and drainage simulation system using particle system technology.

Project Overview

The significance of this project is to research basic techniques to be applied to develop professional geographic information processing software. At that time, many GIS companies already developed their own software. The problem in the country was that geographic data construction is severely concentrated to some areas. Moreover, there is much duplication. This problem comes from the fact that geographic software can’t able to interoperate various kinds of data formats.

In this situation, we solved this problem by developing a GIS software technology that supports interoperability among heterogeneous data formats. This technique is developed by Microsoft COM (Component Object Model) technology. At first year, we designed component model of target software and developed first prototype following object-oriented technique. We developed true COM objects using Microsoft ATL (Active Template Library) and implement component technology so that user can deal with geographic data of various formats.

Project Achievement

The whole aim of this project in general is to develop software, which build 3D geographic data of terrain and facility in urban area from the high-resolution satellite imagery, and process, analyze and distribute spatial information with GIS and virtual reality technology. By using COM technology, we developed the following components: terrain processing and analyzing, spatial information storage management and searching, satellite sensor modeling and shape extraction, dynamic link management of spatio-temporal data, 3D modeling component, and visualization component. In this component, I was involved in 3D modeling component and visualization component and I implemented integrated software with internal management component and 3D visualization component. In this document, I focused on what I researched more that other topics. It includes:

- Tree-implementation for Scene description (Scene Graph)
- 3D primitive modeling (Sphere, Cone, Extrusion, etc)
- Integration between geographic data in database with 3D models

In addition to those, I managed and guided the following joint-developments:

- Development of surface analysis operator
- Research on drainage simulation with parametric surface.

1. Scene Graph

Figure 2 shows the result of scene graph composed of geometric primitives. As the figure shows, scene graph
contains much information to compose a scene. Basically, it has geometric information with appearance attributes, and position and transformation information affect the scene. The transform information has relativity so that we can decide transform with respect to that of the others. Tree structure made possible to decide transform that is propagated by other primitives. So we can find 2 transforms; one is absolute the other is relative. The scene graph manages whole amount of the scene so that user can determine the size of viewing container.

The performance of execution of scene graph is sufficiently reliable. Since 3D geometric information on each node is composed of OpenGL® display list, once it is loaded through memory of graphic device, it is processed in very high speed and don’t need additional projection of each 3D point when the view point of scene is changed.

2. 3D Primitives Modeling

This module supports following 3D primitive: for building modeling, cube, box, sphere, generalized cylinder, and extrusion of arbitrary direction are used. Indexed face set is used in modeling of terrain or road. Spline surface and curve are applied to modeling of curved road or path of camera for flight or driving simulation, respectively. It presents visualization module directly from intuitive input arguments.

3. System Integration and User Interface

This system contains geographic data using database. The database control module supports each floor of a building. I integrated the module with scene graph to visualize each floor, like Figure 3.

It also gave a dialogue of browsing attributes. When selection event happen, this system find appropriate object corresponding to the selection and show its attributes interactively.

For user-friendly interface in GIS related interaction, I implemented direct picking into 3D scene and real-time drawing showing the indication. In Figure 4, the system draws a bounding wire in all drawing canvas. It even shows the object in the canvas for 2-Dimensional map drawing. Moreover, regarding interactivity, we implemented tool-tip operation to canvas of 2D drawing so that a tiny dialogue representing brief information of the object is pop-up.
4. Joint-Research: Surface Analysis and Simulation

As a joint research activity, we collaborated with GISsoft Co. in developing terrain analysis software. Figure 5 shows the results of 4 operators relating to terrain understanding. For being grid characteristic, terrain analysis, if it depends only on local/regional property, didn’t need much time.

Figure 6 shows the result of drainage simulation by Seoul National University. I dealt with interaction between geographic data. In regard to large amount of terrain data, it used Spline surface to find intersection between rainfall and terrain. It gave the property of particle to represent soil and water. During computation, we can trace the movement of each water particle and find how they get together in a place.

Publications