Visualizing 3-D Geographical Data with VRML

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Abstract

This article discusses visualizing and interacting with 3-D geographical data via VRML in the Web environment. For this purpose, the Web-based desktop VR for geographical information is conceptualized. After VRML is briefly introduced, issues in modeling geographical data such as modeling geometry, topology and appearance are addressed. Sample visualization results for terrain and buildings are given followed by discussions on the application of VRML. Cooperation within computer graphics and GIS is prospected in automatic model reconstruction and in exploring VRML application potential in visualizing geographical information.

1. Introduction

Geographical data is uniquely characterized by its three dimensional (3-D) attributes, though it has been conventionally portrayed on various map sheets and managed in database based on 2-D topology. In order to reach good visual effect and effective query, the display of geographical data should be in a 3-D mode and capable of being interacted [6], preferably from different local or global sites simultaneously.

This goal can be reached by integrating advances in computer graphics and Internet technology. Advanced graphical library such as OpenGL and VRML (Virtual Reality Modeling Language)[3] makes it possible to effectively model and thereafter render the third dimension. Particularly, in addition to terrain and landscape, man-made 3-D objects such as buildings can be effectively modeled and rendered with the help of these advances [1,8,9].On the other hand, Internet is widely used as a platform to distribute, query, visualize and process geographical data. Integrating Internet technology with computer graphics enables a simultaneous interaction with the display locally or globally.

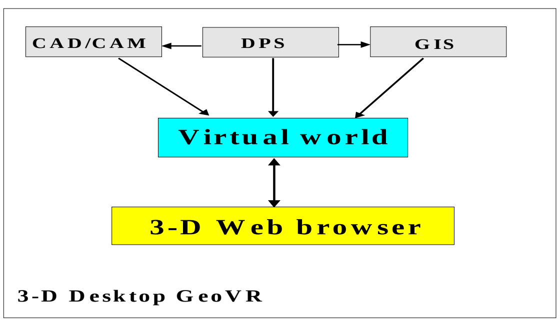
This article discusses visualizing and interacting with 3-D geographical data via VRML in the Web (World Wide Web) environment. VRML is used as the development tool to model, display and interact with, among others, DTM (Digital Terrain Model) and buildings, one of the fundamental components for constructing 3-D GIS [1,6,8,9]. The purpose is to study the methodology and potential to establish a desktop virtual world for 3-D geographical phenomena such as urban or city environment over the Web. The remainder of this article is organised as follows. Section 2 conceptualizes the components of the Web-based desktop VR (Virtual Reality) for geographical information. A brief introduction to VRML is given in section 3 followed by issues in modeling geometry, topology and appearance. Sample results and discussion on applications are then given in this section. Cooperation within computer graphics and GIS domains is prospected in automatic model reconstruction and in geo-application of VRML as the summary of this article in section 4.

2. Web-based desktop VR for geoinformation

VR is the use of computers and other special hardware and software to generate a simulation of an alternate world [4]. It performs a real-time graphics interaction with 3-D models. When combined with a display technology, it gives the user immersion in the model world and direct manipulation [2]. Three primary requirements on a VR system are immersion, interaction and visual realism [7]. This means that a user should feel immersed in the scene, transparently interacting with a visually realistic simulated environment. The desktop VR is currently the most commonly used form of VR systems. It involves the use of personal computers and workstations, possibly incorporated with stereoscopic viewing and sound devices, to create, view and interact with the model of the world.

The Web is an information retrieval system on the Internet. It provides a seamless access to all the information distributed on the Internet worldwide.

The application of computer graphics and Internet technology in GIS results in an integrated system for querying, visualizing and distributing geographical information over the Web. It is conceptualized in this article as Web-based desktop VR for geoinfomation. Its primary components are shown in the following diagram. As is shown in this figure, the geographical data extracted from digital photogrammetric system (DPS) or archived in CAD/CAM and GIS are transformed into a virtual world, which is then rendered over the 3-D Web through the Internet. Thus, one can experience the immersion into the geographical environment through navigating the virtual reality. Meanwhile, the virtual world, together with other geographical data such as attributes, vector data and imagery, can be distributed over the Web in the same environment too.



3. Modeling geographical data with VRML

3.1. Introduction to VRML

In order to render the virtual world over the Web, VRML has been developed and becomes an industrial standard regarding to graphical description of the world over the Internet [3]. With VRML browser, one can interact with the view so that any part of the world, as long as it is modeled by VRML, can be examined in any path at any orientation and at any scale.

VRML uses a hierarchical scene graph to describe the 3-D world [3]. Entities in the scene graph are called nodes. Nodes store their data in fields. Nodes can contain other nodes and may be contained by more than one nodes. By organizing the nodes and specifying their values, one can model the geometry and topology of the geographical information. Illumination and appearance of the world can be defined by corresponding nodes as well. In addition, image textures, which can be obtained from DPS, can be transformed and added on top of the geographical surface, such as terrain and urban area. Another distinct characteristic of VRML is LOD (Levels Of Detail). The world is first defined in different versions of detail. VRML browser can then automatically choose and display the appropriate version of the world based on the distance from the viewer [3,5].

Modeling is to establish a description of the world based on VRML. It is the first step in visualizing the geographical data. A comprehensive description should minimum include the geometry, topology and appearance of the world, illumination condition and viewer attitude.

3.2. Modeling terrain

VRML file accepts raster DTM data as standard input. Based on this raster input, VRML browser can automatically construct the triangular faces and perform smooth shading on them. The degree of face smoothing is also optional [3].

3.3. Modeling buildings

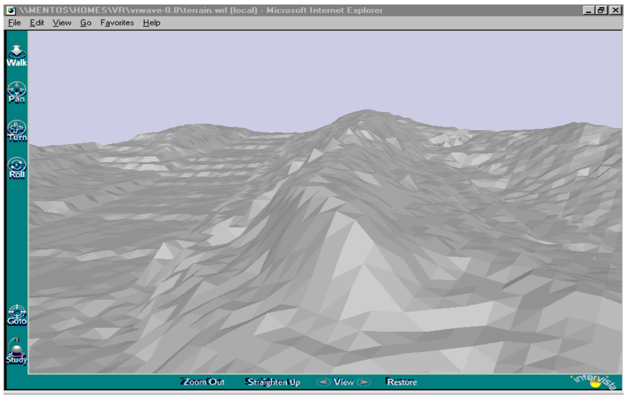
Buildings should be explicitly modeled both in geometry and topology. This is done based on boundary representation principle. In addition to giving the coordinates of vertices composing a building, their connectivity, namely how the faces are formed by which vertices, should also be specified [3].

3.4. Modeling the appearance

The appearance will affect the final effect of visualization. There are various options to choose in VRML, such as the location, direction and type of illumination, reflection properties of the world, types of color and texture, scale etc [3]. To simulate the reality and the circumstances one views the object, directional light from upper-left (north-west) is chosen. The surface of the world is often chosen as having diffuse reflection. Initial attitude of viewing location is also carefully selected so that a proper initial view can be obtained.

3.5. Examples and discussion

Primary tests on visualizing terrain and buildings are done. The VRML worlds are created by text editor. The terrain data is measured on photogrammetric instrument, while the building (part of the campus) data is created based on the blueprints. Following sample figures are selected views of terrain and the campus area.



Terrain

The campus

The appearance of the view depends on browsers used. Different browsers, like Cosmo Player, WorldView, Vrwave have been used, each of which yields slightly different appearance in color, size and orientation and initial location of the view. PC based browsers have advanced functions such as examining particular spot by clicking that location on the view, animating the scene via panoramic view and fly-through.

The distinct characteristics of geographical data is its spatial attribute. All the information is characterized by its 3-D geographical coordinates. However, objects are described based on various local frames in VRML. This, on the one hand, provides the flexibility to model objects individually, bur on the other hand, leaves extra tasks for the VRML designer to perform the transformation among the frames involved. In addition, this also complicates the procedure of getting a proper initial view of the world when the VRML file is first browsed.

Although there are fields in VRML to choose various parameters for the appearance such as color, intensity, types of illumination etc, it seems hard for a non-experienced programmer to handle them properly. An authoring tool is thus needed to reach an optimal visualization effect.

Plug-in browsers are extremely slow when starting to load the VRML file in the Web environment. However, the rendering speed is acceptable once the VRML file is loaded.

4. Summary

Acquiring, visualizing and distributing geographical information are essential for GIS. A Web based desktop VR system will be best suitable for this purpose. It will be an integration of CAD/CAM, DPS and GIS in a desktop environment based on the 3-D Web. Terrain, buildings and their appearance have been successfully modeled and rendered in this article. Cooperation between computer graphics and GIS scientists is expected in two subjects: automatically and effectively reconstruct the VRML model of the world from recorded raw data, and further explore the potential of VRML for visualizing and interacting with geographical information over the 3-D Web.

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