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Virtual Reality & 3D GIS

3D Topological modeling and visualisation for 3D GIS

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Abstract

Beyond Virtual Reality, 3D Geographical Information Systems should provide efficient spatial analysis tools able to use all capabilities of the third dimension, and a visualization that could operate on the results of queries. To address these issues, this paper presents a fully 3D topological model that was implemented in an object-oriented database management system. That prototype uses a 1 : 5,000 scale database where the problems of abstraction and symbolisation arise, and allows a set of semantic, geometrical and topological queries. The results can be visualized after several transformations on some objects of the database to make them more significant.

Keywords: Geographical Information Systems; Third dimension; Topological modeling; 9-Intersection model; Visualisation

1. Introduction

In the past, geographical data were represented only on paper maps and therefore are nowadays usually stored in two dimensions in geographical databases. Nevertheless, the use of the computer medium allows the data to be managed in three dimensions.

Geographical information systems are used in several domains of application: environment, network management (transport, water, gas), agriculture, national and regional development, natural or technologic risks, geology [1,2], telecommunications [3,4]. Lots of these applications have been realised mainly with two-dimensional data. While some of them were quite correctly realised with 2D data, such as network analysis where topology is more important than geometry, most of them cannot be really reliable because geographical objects are not correctly represented in the database. For instance, in telecommunications, or geology, 3D data management is needed.

The first step towards the third dimension is the 2D1/2 management. That model extends 2D database management by adding to each point its altitude as an attribute. This modelling correctly represents the ground in most cases, but fails in particular and significant cases, like overhangs and cliffs. Further, buildings are not well modelled because of their vertical faces. While 2D1/2 is quite suitable for small scale data, i.e., less than 1 : 100,000, because the problematic objects (overhangs, buildings, roads) are too small to be entirely represented, 2D1/2 is not very satisfactory for large scale data, i.e., higher than 1 : 10,000, where the ground and all the geographical objects have to be represented.

On the other hand, regardless of GIS technology, 3D models have been studied and developed, for instance in the architecture domain, with the visualization as main objective. The data are therefore not structured according to a topological model as in a 2D GIS.

So, our main goal is to provide a 3D model for geographical objects by taking advantage of 2D topological modelling knowledge and 3D capabilities for visualization. Nevertheless, visualisation is only an application, and it must not be an objective for 3D GIS [5].

Our 3D model overcomes the limitations of two-dimensional structures. It is able to represent all kinds of geometrical shapes, and to manage topology, i.e., relationships invariant after translation and rotation and stretching, without tearing. That topological information is important to solve spatial queries without difficult calculations. The topological model must be complete,

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