3D GIS: CURRENT STATUS AND PERSPECTIVES

Siyka Zlatanova[1], Alias Abdul Rahman[2], Morakot Pilouk[3]

[1]Delft University of Technology, The Netherlands

s.zlatanova@citg.tudelft.nl

[2]Universiti Teknologi Malaysia, Malaysia

alias@fksg.utm.my

[3]Environmental System Research Institute (ESRI)

Redlands, California, USA

mpilouk@esri.com

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ABSTRACT

Currently, variety of software (2D GIS, DBMS, 3D CAD) is already capable of handling a wide range of spatial problems, beginning with approaches for describing spatial objects to quite complex analysis and visualisation. However, increasing number of applications (e.g. urban planning, environmental monitoring, telecommunications, utility management) need more advanced tools for representing and analysing the 3D world. Among all types of systems dealing with spatial information, GIS has proven to be the most sophisticated system that operates with the largest scope of objects (spatial and administrative), relationships and means to analyse them. In this context, we believe that the 3D GIS will provide the necessary means demanded by the 3D market. However, what is the status of the 3D GIS? It is the aim of this paper to address some of the issues and problems involved in developing such a system.

The development of 3D GIS is not an easy task. Traditionally, GIS maintains information about spatial phenomena and provides means for analysis and thus gain knowledge of the surrounding world. In general, consensus on the demanded functionality of GIS is achieved already years ago. Many authors agreed that it is a type of system able to model, represent, manage, manipulate, analyse and support decisions based upon data associated with real phenomena. 3D GIS has to provide the same functionality as the 2D variant. Nowadays, 2D GISs are common and widely used to handle most of the 2D GIS tasks in a very efficient manner. However, the same kind of systems fail to operate with 3D data if more advanced 3D tasks are demanded. A variety of different software (i.e. 2D GIS, DBMS and CAD) is employed to maintain the objects of interest and extract the required information. Due to deficiency of any of the system to handle 3D objects, the data are spread between several systems. For example, one system is used for data storage and another for 3D visualisation. This situation often faces inconsistency problems, which results in extra time, efforts and money to find the appropriate solution.

A significant step toward the development of GIS applications is the agreement on the manner for representing spatial information, i.e. the OpenGIS specifications. The specifications allow increasing number of DBMS to maintain the spatial data together with the administrative data and thus guarantee the consistency. Currently, only the first step is made, i.e. the implementations focus mostly the geometry. Topological representations and operations (especially in 3D) are still only a wish. What are the problems related to development of functional 3D GIS? In this paper, we focus on three major aspects, i.e.

Topological model: The design of a 3D topological model is a subject of intensive investigations and several 3D models have already been reported. Each of the models has strong and weak points for representing spatial objects. The consensus on a 3D topological model is not achieved yet. The topological model is closely related to the representation of spatial relationships, which are the fundament of a large group of operations to be performed in GIS, e.g. inclusion, adjacency, equality, direction, intersection, connectivity, and their appropriate description and maintenance is inevitable. Similar to 2D variants, 3D GIS should be capable of performing metric (distance, length, area, volume, etc), logic (intersection, union, difference), generalisation, buffering, network (shortest way) and merging operations. Except metric operations, most of the others require knowledge about spatial relationships. Formalism for detecting spatial

relationships, i.e. the 9-intersection model, was also recognised by the industry. However most of the implemented operations consider only 2D cases.

Visualisation, navigation and user interface: Advances in the area of computer graphics have made visual media a major ingredient of the current interface and it is likely that graphics will continue to play a dominant role in the communication and interaction with computers in the future. 3D visualisation within 3D GIS requires a number of specific issues to be considered, e.g. appropriate means to visualise 3D spatial analysis, tools to effortlessly edit, explore and navigate through large models in real time. Observations on the demand for 3D City models show user preferences for photo-true texturing, due to improved model performance in terms of detail and orientation. Trading photo-true texture raises new problems related to collection, storage and mapping onto the geometry. Specific functions of objects modelled in VR systems, and referred to as behaviours, gain an increased popularity as tools for walking through the model, exploring particular phenomena and improving the cognitive perception.

Distributed data and information access: The Web has already shown a great potential in improving accessibility to 2D spatial information (raster or vector maps) hosted in different computer systems over the Internet. New Web standards (VRML, DML) have created the ability to distribute and navigate in 3D virtual worlds. The research on spatial query and 3D visualisation over the Web has already resulted in a few prototype systems and a number of extensions to existing products. The design criteria, however, are visualisation- rather than spatial analysis-oriented.

This paper is organised in the following order. First, we analyse the recent achievements reported by a number of vendors. There are several systems available in the market that can be categorised as systems that attempt to provide a solution for 3D representation and analysis. The systems selected for detailed consideration are chosen because they constitute a large share of the GIS market and provide some 3D data processing functions. These systems are: ArcView (ESRI Inc.), Oracle Spatial 9i (Oracle Inc.), Microstation Geographics (Bentley), Imagine VirtualGIS (ERDAS Inc.), GeoMedia Terrain (Intergraph Inc.), PAMAP GIS Topographer (PCI Geomatics Inc.), and MapInfo. Second, we discuss the attempts of the researchers toward providing an appropriate structures and operations for 3D spatial analysis and visualisation. Final discussion recommends directions and topics for further research and implementations.