Scene Graph Based Approach for Interoperable Virtual Globes

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ABSTRACT

In this paper, a concept for developing and setting up virtual globes is discussed, which is based on principles of interoperable 3D spatial data infrastructures. Open geospatial industry standards for data and web services are merged with computer graphics technology to create a global coherent framework for accessing and displaying 3D assets. The author discusses how the scene graph concept can be used in a Geoweb environment. The Web 3D Service (W3DS) interface is used for streaming data in a distributed web architecture. Using scene graph data structures for encoding, transmitting, and displaying city- and landscape models imposes new requirements to geospatial analysis. The support of transformations between coordinate reference systems is essential in this context. Scene graph transformations are described in detail including matrix calculations. X3D is discussed as potential exchange format. Experiments were conducted using freely available data of OpenStreetMap and SRTM.

Keywords: 3D Graphics, Scene Graph, Spatial Data Infrastructure, Virtual Globe, Web 3D Service (W3DS)

INTRODUCTION

Virtual Globes have partly replaced traditional 2D maps as means of communicating geospatial information and 3D city and landscape data has become more ubiquitous. Due to the huge amount of necessary data, nearly all implementations utilize web technologies and a server-client architecture. Mashups extending established map portals by adding custom content and services have already been created based on Virtual Globes. Currently commercial providers offering free online access to detailed elevation data, imagery, building data, and Points of Interest (POIs) are most successful in this area. User generated content and custom data can be added to these base layers by loading local files. By embedding remote files and server scripting, also dynamic content such as trajectories and live sensor data can be integrated. A basic supply of geographic information may be extremely useful for projects with short term objectives that just want to put their data into a spatial context, e.g., for thematic mapping. The pervasive usage of this kind of mashups is sometimes referred to as the Geoweb (Voloder, 2010), stressing the usefulness of spatial access pattern to other information. Although often additional APIs providing access to geo-coding, routing, and elevation, can be used in conjunction with such frameworks, it must be still considered as centralized approach in which the provider, be it commercial or not, has full control over the base layers, especially

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terrain and imagery. In order to include content that can be seen by everybody without loading extra files, it must be uploaded and hosted by the Virtual Globe provider. That is why many municipalities are reluctant to integrate their existing 3D city models. Moreover, they have usually much higher resolution digital elevation models which they cannot use in a centralized framework.

Efforts to establish national or international spatial data infrastructures (SDIs) focus on the “relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data” (Nebert, 2004). An SDI is more than a single data set or database. It is a distributed system that provides means to discover, visualize, evaluate, and access geographic data, and meta data. Centralized solutions relying on proprietary formats with tightly coupled server and client implementations do not harmonize very well with the requirements of SDIs. Technical solutions must be fully transparent in terms of service interfaces and protocols. Royalty free formats must be used for offline data exchange and online streaming. Most initiatives rely on standards of the Open Geospatial Consortium (OGC). In the 3D world, the European INSPIRE initiative (EC, 2007) embraced CityGML as possible exchange format (GIM, http://www.gim-international.com). GML content can be published through OGC Web Feature Services (WFS). Some fundamental issues regarding service architectures, data integration and visualization in 3D SDIs are addressed by Altmaier and Kolbe (2003).

On the other side, interactive 3D and Virtual Reality applications developed from professional CAD and consumer oriented gaming software. This is also reflected by the way 3D content is created. A well-established concept is to use scene graph data structures (in CAD sometimes referred to as assembly), which allow easy model manipulation and creation of animations. It is often difficult to translate such models into GIS data sets, especially if they contain non-static elements. Many VR applications that are used to display very detailed 3D city models neglect the spatial reference frame and can be only used within a limited space.

In order to re-use existing 3D assets originating from domains such as VR and simulation applications, CAD, BIM, and computer games within a coherent spatial 3D system, the scene graph concept must be taken into account in all stages of the pipeline, from storing, exchanging, streaming, transforming, to rendering 3D data. The design of interfaces must support the rich feature set of computer graphics standards as well as geospatial access patterns and requirements of SDIs. Some operations such as spatial indexing, computing spatial intersections, geometrical analytics, and transforming data from one coordinate reference system (CRS) into another are more complicated to be done on scene graphs compared to traditional GIS data structures. Especially support of CRS transformations is mandatory if data is to be made available to a wide range of client applications and to align it with other data sets.

In this paper I want to discuss how the scene graph concept can be used for implementing a Virtual Globe based on the ideas of open, interoperable, and transparent SDIs. The result is a portrayal oriented pipeline for 3D geospatial data with a focus on visualization using computer graphics technologies rather than on data exchange. The design of the system has been evolved during the implementation that has been carried out for the research project OSM-3D, see OSM-3D (2011), Schilling et al. (2009), and Over et al. (2010). The project combined freely available data in order to create a global landscape model and had the following requirements:

1. Implementation as server/client solution using standard web technologies without the need of bulk downloads.
2. Fully transparent server interfaces that are documented in publicly available specification documents. The server interface must adhere to the principles of the OGC.
3. The web service for streaming 3D content over the web must also be suitable for SDI integration. It must provide means to
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