Procedural Modeling in 3D GIS Environment

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ABSTRACT

3D space registration and visualization has become an imperative need in order to optimally reflect all complex cases of rapid urbanization of property rights and restrictions. Besides, current technological advances as well as the availability of sophisticated software packages (proprietary or open source) call for 3D modeling especially in the GIS domain. Within this context, GIS community’s present demands concerning the third dimension are discussed, while a variety of 3D modeling techniques is presented, with special emphasis on procedural modeling. Procedural modeling refers to a variety of techniques for the algorithmic generation of detailed 3D models and composite facade textures from sets of rules which are called grammars. In this paper procedural modeling is employed via CityEngine software focusing on the 3D visualization of the National Technical University of Athens (NTUA) campus’ three-dimensional model, rendering a higher detail on the School of Rural and Surveying Engineering (SRSE). This algorithmic modeling concept is based on the principle that all real world buildings are defined by rules, since repetitive patterns and hierarchical components describe their geometry. The detailed geometries of the model derived from the application of CGA (Computer Generated Architecture) shape grammars on selected footprints, and the process resulted in a final 3D model, optimally describing the built environment and proved to be a good practice example of 3D visualization.

Keywords: 3D GIS, 3D Modeling, CGA Grammar, CityEngine, Procedural Modeling

1. INTRODUCTION

Contemporary urban environment is distinguished by its structural complexity and the multiple use of space in which a range of different RRRs (Rights, Restrictions and Responsibilities) intersect with the corresponding land parcels. This range of land rights, restrictions and responsibilities requires proper 3D registrations complying with each legal structure, as well as systematic encoding and modeling, fully exploiting technical capabilities of 3D representations (Dimopoulou & Elia, 2012). This 3D representation of the composite urban cityscape or the mixture of information in land management systems is a rather laborious and
a challenging task and generally constitutes a rather expensive and time-consuming process, both for the modeling approach as well as the effectiveness concerning the generation of suitable texture facades of edifices. Furthermore, spatial relations and constraints between real world objects of this multidimensional build environment need to be translated and to be modeled adequately within a geometric and a topological concept and have to be incorporated within a semantics basis.

Therefore, the constant need of the modern world to better comprehend and enhance the perception of the real world’s entities and phenomena through technological advancements has become clear. This profound need has led us to the description of our physical animate and inanimate surroundings in a higher dimensionality, both in theoretical and technological fields. Evidently, developments in one domain inevitably influence various different research fields and encourage the genesis of new questions related to the correctness with which we distinguish, describe and finally model the world. This constitutes a more pressing matter when we refer to GeoInformation sciences, where difficulties and questions relentlessly arise throughout the geographic information management process, making 3D or nD modeling and visualization a necessity and a continuous demand by the GIS community.

The use of three-dimensional features has considerably increased during the last decade in various computer based fields, leading to the emergence of 3D modeling software where new or old packages (proprietary, open-source or free) are available, occasionally improved with more refined 3D features. A variety of current GeoInformation software aims to the manipulation of 3D data and the management of 3D models, while land management systems have been enriched with IT tools, capable of collecting and processing data originated from the 3D complex-structured environments. The emergence of novel 3D modeling methodologies and techniques in computer graphics as well as the development of a range of 3D file formats that sustain interoperability and promote the distribution of information between different CAD and GIS packages has certainly assisted in this direction. The appliance of 3D geometric, topological, semantic models is gaining more and more ground leading to the introduction of the first 3D semantic model, CityGML which supports the third dimension in terms of geometry and topology as well. New web-based visualization environments such as Google Earth and Microsoft Virtual Earth have also made the access to and visualization of 3D data understandable for a large audience (Zlatanova, 2009), while current trends focus on nD approaches such as 4D/5D modeling for the conception of time and scale in geographic phenomena and their integration within a robust system.

The employment of the vertical component is now consolidated, being used in international standards such as Land Administration Domain Model and INSPIRE Directive. Especially in the cadastral domain various prototypes and pilot programs related to 3D visualization have been developed using technologies such as spatial databases, CAD and GIS front-ends (Shojaei et al, 2013).

What is more closely related to the subject of this paper besides the whole new state-of-the-art viewpoint provided by the technological advances in 3D modeling, is exploring and evaluating the prospects of procedural modeling method, using CGA grammar rules. According to Müller et al. (2006) procedural modeling using shape grammars is capable of efficiently creating large cities with high geometric detail and up to billion polygons. Besides, recent techniques in computer graphics are interested in efficient large-scale modeling, but these techniques do not normally allow to establish a very close resemblance to a real environment (Müller et al., 2007), with few exceptions including procedural generation. That is because their grammar based solution generates detailed building shells stemming from complex mass models, since context sensitive shape rules allow the user to specify interactions between the entities of the hierarchical shape descriptions (Müller et al., 2006).
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