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THREE DIMENSIONAL MODELS OF THE CITY TERRAIN REPRESENTATION

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ABSTRACT

Recent developments in computer technology and the availability of digital databases have made it much easier to generate landscape visualizations that can be used to support decision making on urban planning. Computer technology, computer graphics, and computer-aided design (CAD) now offer powerful tools for creating and visualizing digital models of cities. This paper reviews the urban landscape elements, as they may be visualized using GIS software. For the basic landscape elements some standard techniques for convincing static visual representation have been developed.

KEYWORDS: Urban Landscape, 3D visualization, GIS, Computer Graphic, Computer-aided Design, 3D Structures Modeling.

INTRODUCTION

Dense urban environments demand the use of comprehensive GIS to support municipal planning activities. It is necessary to use 3D for representing fully spatial reality and removing some ambiguities in current GIS.

Computer technology has brought a revolution in visualizing maps, plans, and 3D architecture. Now many tools or software are available for creating

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three-dimensional representations of real or planned designs. Computer-generated 3D images are a relatively recent phenomenon utilized in urban planning. 3D visualization is one of the most natural ways to communicate [7]. The public understands these scenes and buildings intuitively, without any knowledge of cartography or having to decipher map symbols because 3D visualization closely imitates a real life experience of the built environment.

Along with the development of computer technique, especially in 3D graphics and visualization, people have ability and deeply wish to increase 3D function in 2D GIS system in order to realize 3D display, manipulation and analysis for more and more application requirements. Also, 3D modeling and visualization are important techniques of Digital Earth which is presented in recent years [9].

The most used 3D models of the city environment are: landform, vegetation, structures and animals (including people) [2]. Each of these elements presents its own challenges in modeling, and fertile areas for research and development. Real as well as designed city terrains are almost always a combination of some or all of these elements together. This paper presents some of the issues for illustrative and realistic representation of the essential city terrains elements.

1. CITY TERRAIN ELEMENTS

Landform typically requires large digital data sets, and so terrain and site modeling have historically been associated with GIS, rather than CAD, and assumed to require larger computers, more memory and faster processors than other modeling tasks [1]. Whereas CAD was initially concerned with points, lines, planes, cubes and cylinders, terrain modeling has depended upon a variety of representations and mathematical abstractions, from spot elevations and contour lines, to 2D grids and 3-D meshes, ruled surfaces, triangulated irregular networks (TINs), regular and irregular solids, Boolean operations and NURB surfaces. The grid representation, the basis of all Raster GIS enables a wide range of analytic calculations, including slope, aspect, visibility, drainage, and others. As a visual representation, grids suffer from two basic flaws: a requirement for constant spacing which is inefficient when surface variation details are few, and inadequate when details are many; and the fact that the four points of a grid cell may not be planar, but more often form a complex curved surface (hyperbolic paraboloid), which poses problems for simple computer graphics rendering algorithms that depend upon flat planes for rapid calculation of, for example, surface normals and shading. TINs overcome both of these problems, and so have mostly overtaken grids as the representation of choice for visualizations [8].

In addition to the shape of the surface, as determined mathematically by mesh, TIN or otherwise, for visualization purposes a visible surface texture and colouring are also required. Asphalt, concrete, brick and other regular tilings are the easiest, but even these cause difficulties in rendering. Often the 'edge-match' of a tiled surface is visible, or the repetitive pattern is visible enough to be disturbing.

Most rendering programs don’t have good texture-scaling capabilities, so that textures that work well in the mid- and background, look distorted, out of scale and out of focus in the foreground. Getting a simple 'grass' surface is not something that is yet commonplace in digital landscape modeling. One solution for these texturing problems is presented by 'procedural' texturing approaches, that generate surface features (or pixels) 'on-the-fly', rather than depending on a simple 2D image to be used. Typically, these require greater processing power and longer rendering times, but promise greater control over scale-dependent-detail and (possibly random) variation.

Representing vegetation – whether trees, forests, or grassy groundcover – is a daunting challenge, in any medium, but especially when counting polygons! Whereas an ordinary building might be well represented with several thousand polygons and simple geometric primitive solids, no part of a plant is flat, square or even really cylindrical. Millions of polygons – or even greater orders of magnitude – are required to begin to capture an ordinary tree, with its fractally complex branching and articulation – and a forest represents a greater numerical and visualization challenge yet [6].

While some software exists for generating 3D solid models of plant forms, these are typically not integrated in to GIS, and are typically used only by a subset of specially interested or motivated illustrators. More common by far is the ‘bitmapped billboard’ technique, in which a photographic image of a tree is projected onto a transparent flat plane in the scene. This method is available in every CAD or rendering package today, and provides a very good general facility for bringing photographic detail into a scene without too great a polygon count. The method is general – the same method can be used for people, cars, streetlights, and etc. – and extendable: a forest can be rather simply modelled by a sufficient number of these texture-mapped planes. This is the most widely used technique for generating vegetated and forested landscape scenes.

Fig. 1. Digital rendering of vegetation on landform

A major limitation of this and most other techniques is that they cannot capture or reflect dynamics in the landscape—trees growing, dying, blowing in the wind, or co-evolving to maximize exposure to sunlight. Growth of trees or shrubs – a simple fact of the landscape, and a major contributor to visual quality over time - is hardly addressed at all in any modern software except in the most cartoonish way. Thus, it may be possible to substitute different tree symbols (circles of different sizes in plan, or texture mapped photographs of different growth stages in elevation) as function of time, but no tree in any CAD or GIS system ever died from crowding or natural causes; and none has yet grown lopsided from environmental factors.

Modeling of 3D structures is inherently the domain of CAD, rather than GIS software [4]. GIS has long been constrained by the essentially 2D or 2.5D data sets at its core; few buildings are so constrained. Many however, are simple extrusions of polygon plans; some even have flat tops, and many have simple roof structures that can be approximated with TIN like representations. So, with the addition of some texture mapping, the ‘extruded plan’ approach found in some software like ArcGis 3D Analyst, works well for many cases [5].

For ‘real’ buildings, CAD models are necessary, but for illustrative geo-typical representations, of neighbourhoods, cities, or regions, the extrusion method works quite well. Mostly, in GIS-based visualizations, the ‘illustrative’ is the goal; but with rendering software coupled to CAD modeling systems, the geo-specific is clearly possible, and some very detailed representations of campuses and cities have been made.

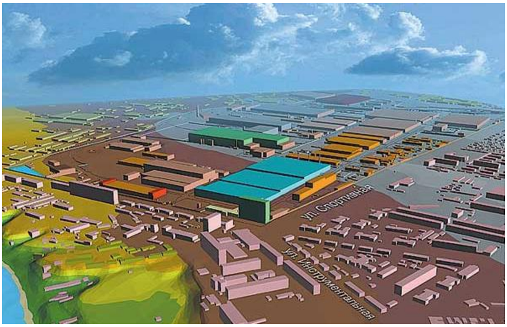

Fig. 2. Visualization of city by extruded polygons. [10]

Animals including people are essential elements of most natural or designed city terrains, even in indirectly or invisibly [3]. Modeling the appearance of animals is just as hard as other landscape elements, for many of the same reasons: fuzzy, curved, complex, dynamic features. And their behaviour is all the more difficult to represent, much less comprehend! For almost all animals, only the 'illustrative' is ever attempted in landscape visualizations.

Fig. 3. People in the Urban Landscape

2. CONCLUSIONS

- The challenges of city terrains visualization arise in part from the sheer complexity of landscapes – in size, in curviness, in fractal dimension, and so on. Some of the problems come from the need to integrate several different sources of material, or techniques – terrain data from GIS, with models from CAD and textures from image processing software, for example. But to the extent that these challenges can be overcome by ever faster computers, larger disks, cheaper RAM, better software and more clever algorithms.

- The considered software is useful modern tool in the field of planning, construction and representations of city landscapes.
- Integration of various products in general 3D visualization of city planning is an important educational and applied problem.

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