Modelling a virtual urban environment with realistic terrain features

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Abstract

Most of the urban models nowadays consider towns as a flat area without sloping zones. However, in order to obtain a realistic model of a city we need to include the information provided by its Digital Elevation Model (DEM). A global representation using the surface topography and the information usually given by an urban GIS (the geometry of buildings, blocks and streets and additional data about street names, number of floors in buildings, etc.) could provide realistic 3D models of urban environments. Nevertheless we find many non-solved problems to deal with, which we address in this paper and provide some research directions.

Keywords

Urban; City; Digital Elevation Model; GIS; 3D

1. INTRODUCTION

Expeditious modelling of urban environments has been introduced in [Parish 01] demonstrating that a simple initial data set could generate complex virtual environments, although with low visual fidelity. Further developments in this area, using geospatial L-systems [Coelho 07]or split grammars [Wonka 03, Weber 09], resulted in higher levels of visual fidelity and detail, specially in the modeling of buildings [Müller 06] and streets [Chen 08].
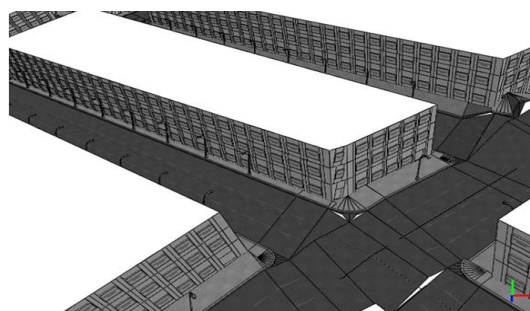

Figure 1. An impossible sloping street

Many towns as, for example, Jaén in Spain or Covilhã in Portugal, are partially or totally built on sloping grounds. Nevertheless, most virtual representations of urban environments assume that the city is set up over a plain terrain. Thus, when navigating these 3D models without realistic terrain features, the sense of immersion can be decreased to such a level that the user may cease to recognize the urban environment.
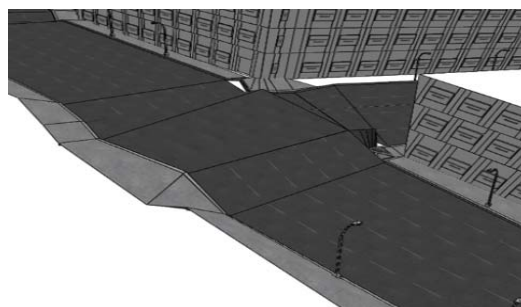

Figure 2. An impossible crossroad

2. PROBLEMS MODELLING TERRAIN FEATURES

In this Section we describe the main problems found to obtain a realistic 3D model of an urban environment when integrating terrain morphology (using DEM information) in procedural modelling.

Streets are one of the most relevant elements in the modelling of an urban environment as several restrictions apply to them. An important restriction in streets is that its slope should be considered mainly over the main axis and not sideways, otherwise it can decrease the level of realism, as can be shown in Figure 1.

Crossroads are also a difficult element to consider as distinct streets that converge can have different slopes, and so it may generate strange effects and inconsistencies on the street profiles, as can be seen in Figure 2.

When modeled as a flat plat, the urban geometry can be

simplified without loss of accuracy using 2.5D objects in most of the cases. This representation uses the footprint and the height of the buildings [RO09]. However, the placement of a block of buildings using the DEM information is more difficult because, although the model of the entire block is flat, we must often locate and place it into a sloping street (Figure 3). So, to properly locate a 3D model of a building in the city, we could modify its vertical position when we include the DEM information accordingly to the streets slope. So, a simple solution for the block problem would be partially burying each of the buildings in the block at its lowest height. However, this solution introduces new problems in the modelling of the building facades since, although the street is sloping, the facades should always be horizontal and its elements like windows and doors could not appear cut or buried. So these issues must be taken into consideration when positioning facade elements or generating facade textures.
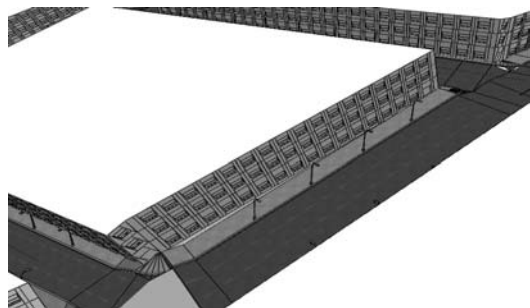

Figure 3. An impossible sloping building

In an urban model we have some different elements: blocks, buildings, streets, crossroads and pavements, among others. As with the buildings, the placement of additional auxiliary elements could be changed when we include the DEM information. However, these elements are necessary to obtain a high level of realism in a 3D model, so we have to design a way to include them.

3 RESEARCH DIRECTIONS

The DEM is an approximation of the real terrain and often it is not suitable to the modelling of most urban features. So the DEM must be adapted accordingly to the other urban features, in order to attain a significant level of realism. New challenges in modelling virtual cities must then be faced, that we summarize in this section.

Streets should be considered first in the modelling process and their geometry must be simplified in order to fulfill most restrictions. Each street should be broken by its intersections and the slope of each street segment calculated by the slope of the line connecting both endpoints, considering the DEM height at each one. Because each intersection or crossroad can connect street segments with different slopes, a flat platform should be used in the common cross area. Sidewalks should follow street geometry and the blocks must adapt to it for continuity of the terrain surface. Buildings and urban furniture should be buried at minimum height so that no breach is visible, although

special care must be taken on the facades as stated in the previous section.

4. CONCLUSIONS AND FUTURE WORK

Including DEM information in a virtual urban environment is a relevant research area in Computer Graphics. If we want a realistic model, then we have to deal with the problems described above accordingly to the directions given. So, as future work we intend to address these issues in order to derive a methodology for modelling virtual urban environment with realistic terrain features.

5. ACKNOWLEDGEMENTS

References

[Chen 08]   Guoning Chen, Gregory Esch, Peter Wonka, Pascal Müller, and Eugene Zhang. Interactive procedural street modeling. *ACM TRANSACTIONS ON GRAPHICS*, 27(3), Aug 2008. ACM SIGGRAPH Conference 2008, Los Angeles, CA, AUG 11-15, 2008.

[Coelho 07] A. Coelho, M. Bessa, A. Augusto Sousa, and F. Nunes Ferreira. Expeditious modelling of virtual urban environments with geospatial l-systems. *Computer Graphics Forum*, 26(4):769–782, 2007.

[Müller 06] Pascal Müller, Peter Wonka, Simon Haegler, Andreas Ulmer, and Luc Van Gool. Procedural modeling of buildings. *ACM Trans. Graph.*, 25(3):614–623, 2006.

[Parish 01] Yoav I. H. Parish and Pascal Müller. Procedural modeling of cities. In *SIGGRAPH '01: Proceedings of the 28th annual conference on Computer graphics and interactive techniques*, pages 301–308, New York, NY, USA, 2001. ACM.

[RO09]   M.D. Robles-Ortega, L. Ortega, and F. Feito. An exact occlusion culling method for navigation in virtual architectural environments. In *IV Iberoamerican Symposium in Computer Graphics - SIACG (2009)*, pages 23–30, 2009.

[Weber 09]   Basil Weber, Pascal Müller, Peter Wonka, and Markus Gross. Interactive geometric simulation of 4d cities. *COMPUTER GRAPHICS FORUM*, 28(2):481–492, 2009.

[Wonka 03]   Peter Wonka, Michael Wimmer, François Sillion, and William Ribarsky. Instant architecture. *ACM Transactions on Graphics*, 22(3):669–677, 2003.