Sharing 3D City Models: An Overview

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Abstract. This study describes the computing methods now available to enable the sharing of three-dimensional (3D) data between various stakeholders for the purposes of city modeling and considers the need for a seamless approach for sharing, transmitting, and maintaining 3D city models. The study offers an overview of the technologies and the issues related to remote access, collaboration, and version control. It builds upon previous research on 3D city models where issues were raised on utilizing, updating and maintaining 3D city models and providing access to various stakeholders. This paper will also describe a case study which is currently analyzing the remote access requirements for a sustainable computer model of NewcastleGateshead in England. Options available will be examined and areas of future research will be discussed.

Keywords. 3D City Models; sharing; remote access; Virtual NewcastleGateshead.

Introduction

Research shows that 3D city modeling, often incorporating Virtual Reality (VR) technologies, as a tool for urban planning is becoming increasingly utilized worldwide. 3D city models, photographic models and VR models can be found across the North, South and Central America, Europe, Asia, Middle East, Africa and Australia. Recent research seeks to identify current practices and trends in city modeling, identifying participants and their roles, and issues relating to the sustainability of the city modeling process (Podevyn et al, 2009).

3D City Modelling

3D and VR urban models have been described as computerized graphical representations or visualisations of any city and its components (Thompson E. et al, 2006). These are either being developed in-house by city authorities or are being commissioned to third party visualization companies, research institutes or universities. 'The initial methods of designing such models were based on computer-aided architectural design from an empirical perspective, where detailed measurement of the geometry was regarded as essential but most of them failed to provide spatial analytical functions' (Shiode and Yin, 2008) that one would associate with Geographic Information Systems (GIS).

Developing these models requires modeling time and computing power. Bourdakis (2008) categorizes the 'methods of acquiring urban scale 3D digital data into five divisions:

- Aerial stereo photogrammetry
- 3D GID pseudo model
- 3D Laser scanning
- Street level modeling using moving vehicles

- Street level photogrammetric technique mixed with digital plans and other sources'.

Shiode and Yin (2008) explains 'six levels of geometrical content for digital representation of cities:

- 2D digital maps and aerial photographs,
- Panoramic images,
- Block extrusion,
- Block models with textures, models with some roof morphology,
- Full volumetric CAD models'.

Model construction time, cost and usability of these digital representations in various applications would differ widely from one to another. However, whichever way these models are created there is no permanent end result. Like real cities, 3D and VR models ought to be organic structures that need to change, evolve and develop continuously.

Although it is believed that 'practically all the existing digital models of built environment are static in the sense that they represent the condition of a city only at one specific time point' (Shiode and Yin, 2008), there are some examples around the world attempting to visualize a city in different time points. Jepson and Friedman's (2006) work on UST Urban Simulator for the city of Los Angeles, where they applied temporal features to visualize the city in different times in its history, is one of them. This type of dynamic model 'will allow users to interpret the growth and the change of a city from the geographical, planning, economic, and sociological, as well as historical and archeological viewpoints in intuitive fashion' (Shiode and Yin, 2008).

Recent research, analyzing the need for urban models, stresses that 'not a single type of 3D digital model is suitable for all applications' (Bourdakis 2008). Bourdakis continues to explain that level of accuracy, texturing and populating the model, level of detail, size of the model and level of realism would differ from model to model. The authors of this paper believe that there is a need to have 'a more functional and flexible city model where various stakeholders can access and utilize the model according to their needs' (Thompson et al. 2006). Recently it has been suggested that 'cities worldwide are attempting to move from isolated modeling workflows for geospatial features, planned building construction, and utility assets toward and integrated digital representation of entire urban fabric that enables a completely new approach to managing cities and facilitation by the public in the urban design process' (Andrews, 2009). All these requirements and ambitions for 3D city models bring many challenges such as; procedures for maintaining an up-to-date model and sharing this model with various stakeholders, types of output required, the geographical coverage of the city model, issues regarding data collection, clients' requirements, budget, network, software and hardware related issues etc.

Emerging Issues

As previous research shows, the use and functionality of 3D city models can be very diverse and it is believed that new generation of city models will most likely be created by combination of different techniques using various digital technologies to achieve different levels of content (Dokonal 2008).

3D city models can be used for "planning and design related activities, infrastructure and facility services, marketing, promotion, tourism, data source for planning applications, surveying, maintenance and development plans, teaching, learning and research activities" (Thompson et al. 2006) and historical reconstruction of cities, entertainment related activities, urban information modeling etc. Rapid and reliable creation of 3D models of large-scale urban environments that are created with

multiple sourced data can be classed as the initial challenge. However the different functionalities and their various requirements would make these 3D or VR city models almost impossible to transmit over the internet as a single complex dataset. There are other constrains that effects the sharing and real-time visualization of large graphic datasets such as network and end-user computer capabilities. There is also the problem of updating the ever-changing city data and long-term maintenance of the city model.

Remote Access

Location independent, shared spatial data enables 3D models to be visible and accessible to various user groups who need to collaborate. Examples like Google Earth, Microsoft Virtual Earth and Yahoo Maps etc. demonstrate the importance of being able to visualize and interact with the geographical data in the public domain. However these applications also emphasize the need for more accurate virtual cityscapes for rigorous detailed analysis of the built environment, and the above applications are not appropriate for many of the purposes mentioned previously.

Rosenman et al. (2007) emphasize that, 'digital collaboration and remote sharing raises issues such as: version control, ownership of models, tracking, recoding and transmitting design decisions'. Similarly it can be said that data sharing has been a challenge addressed by many other industries, and the remote sharing and accessing of 3D digital data is one of the major issues emerging for the city modeling process.

Ultimately, remote spatial collaboration should encompass 'supporting joint control of displays by multiple users, representing users and their behaviors and integrating verbal and visual communication for different–place collaboration' (Brewer et al, 2000).

This paper will focus on two levels of access to 3D city data: Basic Access and Complex Access. These two levels of access are considered necessary for the different functionalities required of 3D City models as mentioned previously.

Basic Access

There are new and emerging applications that provide the capability to share a 3D model on the web quite easily and one such application is TurnTool. This application is a real time 3D graphics solution to share 3D content over the internet. It works as a plug-in for software such 3DsMax, Cinema4D, ArchiCAD, and AutoDesk Viz. One of the main objective of using these types of applications is download size can be kept to minimum level but in the mean time the 3D Model will have high quality. The TurnTool viewer that works as an ActiveX controller and can be integrated with Microsoft Internet Explorer, Microsoft PowerPoint etc. With these types of tools 3D models can be transmitted and end users can interact with the 3D model with ease-of-use. Such computer tools and capabilities are allowing lay people to see the models from different perspective, pan, rotate, walk, fly over and take screen shots if necessary.

Web-enabled versions of city models enable city authorities to provide and share information about a city to their residents within their already established websites. Many of the requirements from a city model, such as those arising from economic and community regeneration, e-government, transport and traffic management, conservation, education and training, and participation and democracy can be integrated to this type of application. For this type of access network and end-user computer capabilities need not become a major issue if the versions of the 3D city models are optimized and not highly detailed (Figure 1).

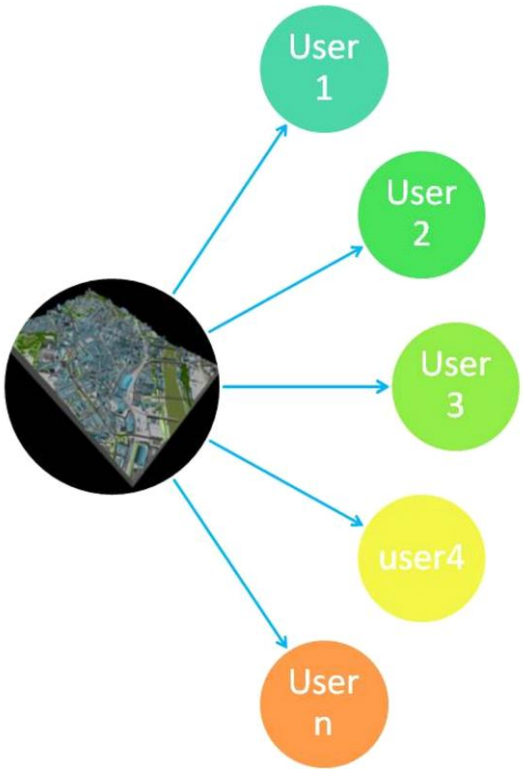

Figure 1
Basic access to the city model

Complex Access

This type of access is more in line with the term "collaborative geovisualization". This is 'to involve a committed effort on part of two or more people to use geovisualization tools to collectively frame and address a task involving geospatial information' (Brewer et al, 2000).

For more accurate usages such as those required for urban planning applications etc., there is a need for a more secure and remote 2D and 3D real-time interactive data exchange to enable collaboration between planners, architects and decision-makers. With more sophisticated software and network applications emerging, complex models can be securely accessed to allow remote data sharing such as text, complex graphics, and / or real-time video across standard network structures. Hewlett Packard's Remote Graphics Software is such an application that would allow users to securely interact with 3D models without the modeling software and data on the viewers' workstations.

Virtual NewcastleGateshead Project

Issues and options relating to the remote access of 3D city data are currently being explored in relation to the creation of a virtual model of two adjacent cities, Newcastle upon Tyne and Gateshead, in the north east of England in the UK. The concept of a virtual city model of Newcastle upon Tyne can be traced back to the mid 1990s, and many three dimensional computer models have helped to portray major development proposals since that time. However these instances of 3D computer modeling, whilst demonstrating the benefits the technology can offer, have been isolated projects and

not integrated into any larger urban model. Many such projects have been commissioned by clients to strengthen planning proposal submissions for major developments. This process represents an approach typical for many UK cities where parts of the city have been modeled, resulting in a jig-saw of 3D models, often using incompatible computer platforms and diverse scales. This is one of the economic drivers for the creation of one single definitive, authoritive, interactive model of both the cities of Newcastle and Gateshead. As acknowledgement of the advantages of utilizing 3D city models becomes more widespread it is likely that an increasing number of interested parties will require access to respected city models, as an economical alternative to creating a number of different models. This need to strive for a more efficient solution, together with advances in computer hardware server technologies, collaborative software solutions, increased 3D modeling in practice and developments in digital rights management have resulted in NewcastleGateshead seeking a different approach. The Virtual NewcastleGateshead project is being developed by a working party set up to examine the strategic implications of addressing this challenge, and has focused on identifying issues pertaining to ownership, management, update and sustainability of a city model (Horne 2009). A detailed study of the requirements of identified key stakeholders identified remote access, model version control, and sharing of city data as key requirements, and has resulted in a further analysis of the technical solutions emerging, and computer methods now available to meet these requirements.

Current Situation

Northumbria University, School of the Built Environment has been developing a 3D model of NewcastleGateshead for the purposes of education and research, and has used this model to raise awareness of the benefits and potential of the technology to the city authorities of Newcastle and Gateshead, both currently challenged by significant levels of regeneration activity. The model currently covers an area of 8 sq km and original data was provided by UK data provider ZMapping. The university has optimized this data and uses software platforms AutoCAD, 3DS Max and VR4MAX for modeling different levels of detail and enabling interaction with the model. This model can be displayed to individuals or groups of people in the School's Virtual Environment facility. This facility supports interactive navigation, stereoscopic projection and is based upon PC hardware.

Figure 2
Sharing city model data in a collaborative environment

The software platform of VR4MAX also enables parts of the interactive model data to be extracted and distributed in a read-only format for viewing on other remote computers, subject to appropriate end user licensing agreements being put in place with the provider of the original data. These other remote users do not require a license of VR4MAX on their computers to do this, and control is maintained on what the end users can and cannot do. Extracting data from the larger model is currently done in house by the modelers who have optimized the original model data.

The above processes of sharing data have been piloted with urban planners within Newcastle and Gateshead Councils and have been used to verify the accuracy of the city model data, an essential requirement if the model is to be used within the urban planning process. The pilot studies have included meetings to take place with architects, clients, planners and regulatory bodies and have furthered understanding on how a Virtual NewcastleGateshead could become embedded into the existing planning process (Podevyn et al, 2008).

Future Proposal

As well as accuracy, remote access and model version control being identified as key requirements of the city model, the need to support citizens' access to the model and participation in the urban design process was also identified as a key requirement. Model data required for sharing with the general public as well as urban planners necessitates different hardware and software solutions to be considered, yet both will be based upon the same underlying (accurate) geometrical data set.

Figure 3 illustrates a proposed structure for remote access for the Virtual NewcastleGateshead based upon the currently utilized software platforms of AutoCAD, 3D Studio Max, VR4MAX as well as proposed use of Turntool to enable an interactive model to be placed on the web.

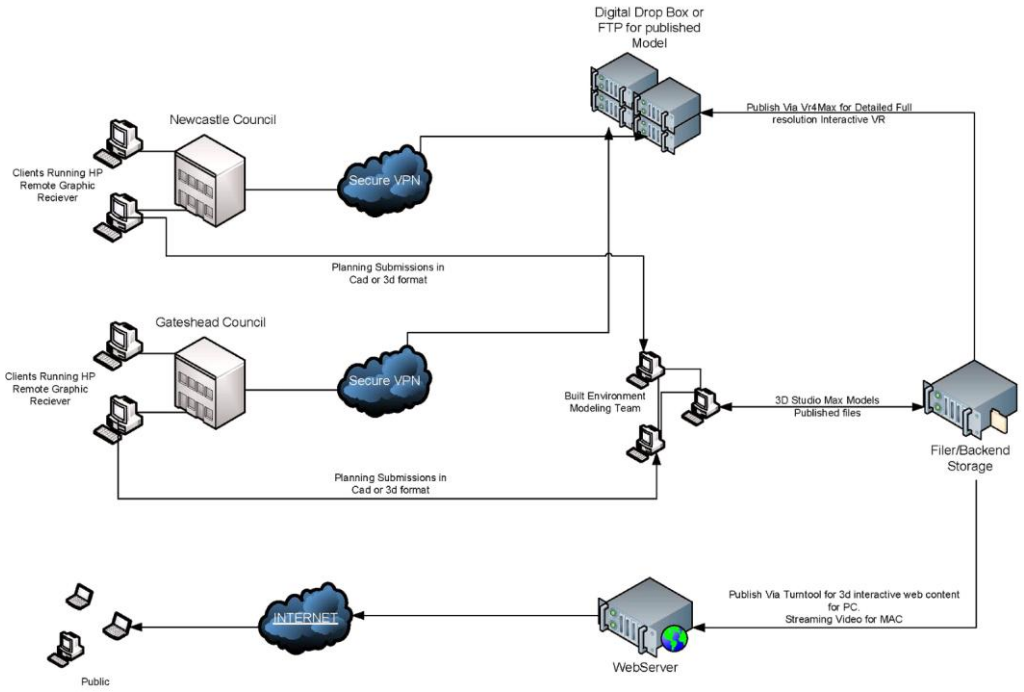

Figure 3
Planned Structure for Remote Access for Virtual NewcastleGateshead Model (Image created by Philip Aitman, Northumbria University)

This proposed structure follows an evolutionary course in that it is building upon commercially available technologies that have been tried and tested, and that will offer a way for Virtual NewcastleGateshead to remain compatible with the software and hardware solutions typically used by architects and developers in the region. However it has been recognized that technologies are emerging which are offering new solutions for the creation and management of models required to be shared with many different stakeholders. Virtual NewcastleGateshead having made progress on addressing some of the organizational workflow issues, plans to investigate and pilot Autodesk's LandXplorer Studio Professional, VR4Max's Conferencing, Met Geo Info's CityGRID as part of a proof of concept study in establishing the most appropriate technologies to meet the requirements.

Integration of the 3D city model data with existing GIS has also been identified as a key requirement. GIS is widely used in public administration (Strobl, 2088) and initiatives such as INSPIRE (Infrastructure for Spatial Information in Europe) has a principle which emphasizes that spatial data from different sources should be combined seamlessly and shared between different users and applications.

Concluding Remarks

This study has offered a current overview of the computing methods that enables sharing 3D city data for different users and purposes. This study also emphases the need for a seamless approach for sharing, transmitting, and maintaining 3D city models.

The case study of Virtual NewcastleGateshead has offered insights into requirements for sharing 3D city models, both from the citizens' perspective for public participation purposes and from city authorities' perspectives for urban planning and design requirements. Progress to date has been the result of a programme of awareness raising which has built the optimism, trust and industry cooperation necessary for a project of this size.

Future Research

Future research will report on feedback gathered from the pilot studies relating to the interactive sharing of urban city models and issues pertaining to organizational workflows. Digital rights management, in support of software, data and other resource licensing agreements, will be a key area for future investigation and will contribute to the move from "partial city modeling" towards a more integrated approach to managing, updating and sharing city data between diverse stakeholders.

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References (max. 12)

Andrew, C.: 2009, Salzburg is Hands-on in Digital Cities Project, Cadalyst GIS, February 2009, http://gis.cadalyst.com/gis/content/contentDetail.jsp?id=581989 .

Bourdakis, V.: 2008, Low Tech Approach to 3D Urban Modelling, architecture 'in computro', eCAADe 26 proceedings, Antwerp, pp. 959-964.

Brewer I, MacEachren A.M., Abdo H, Gundrum J, Otto G.: 2000, Collaborative Geographic Visualization; Enabling shared understanding of environmental process, Proceedings of the IEEE

Symposium on Information Visualization 2000 (InfoVis'00), http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=885102 .

Dokanol W.: 2008, Creating and Using 3D City Models, architecture 'in computro', eCAADe 26 proceedings, Antwerp, pp. 223-229.

Horne M.: 2009, A Tale of Two Cities: A Strategic Approach for City Modelling on a Regional Scale, CUPUM09 11th International Conference on Computers in Urban Planning and Urban Management, Hong Kong, 16th -18th June 2009.

Jepson W., Friedman, Scott.: 2006, "A Real-time Visualisation System for Large Scale Urban Environments", School of Architecture, UCLA, Los Angeles, CA, (http://www.ust.ucla.edu/~bill/UST.html) .

Podevyn M, Horne M, Fisher P, Thompson, E.: 2008, Global Visualisation Engines – Issues for Urban Landscape Planning Participation Processes, Digital Design in Landscape Architecture 2008, Proceedings at Anhalt University of Applied Sciences, 29-31 May 2008

Podevyn, M, Horne M, Fisher, P.: 2009, Virtual Cities: Management and Organisational Issues, CUPUM09 11th International Conference on Computers in Urban Planning and Urban Management, Hong Kong, 16th -18th June 2009.

Rosenman, M.A., Smith, G., Maher, M.L., Ding, L., Marchant, D.: 2007, Multidisciplinary collaborative design in virtual environments, Automation in Construction, 16(1), pp 37-44.

Shiode, N. and Yin, L.: 2008, Spatiotemporal visualization of built environment, in K. S. Hornsby and M. Yuan (eds), Understanding of Geographic Domains, CRCPress-Taylor & Francis Group, pp.133-150.

Strobl, J. : 2008, Status of GIS in Europe - Opportunities and Challenges. In: GIS Development, Vol. 12, Issue 1: pp. 44-47.

Thompson, E.M., Horne M., Fleming D.: 2006, Virtual Reality Urban Modelling-an Overview, CONVR2006 6th International Conference on Construction Applications of Virtual Reality, Orlando, Florida, USA, 3-4 August 2006.

http://www.citygrid.at/index_eng.php

http://www.3dgeo.de/landx.aspx

http://www.ec-gis.org/inspire/

http://www.vr4max.com/

http://www.zmapping.co.uk/