Models for Creating the Prospective City

Opportunities and challenges of 4D GIS and virtual environments

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Abstract. *In this paper, we discuss the different applications of virtual city and environment models within different frameworks and try to reveal their important qualities in relation with their approaches for creating prospective urban developments. Certain uses of urban models and technologies are examined through seven critical cases with a focus on (what) is being modeled, place (where), actors (who), date (when), objectives (why) and approaches (how) adopted for design and development. In the elaboration part, we evaluate and comparatively discuss the interrelated conditions or circumstances that form the setting for these models. In conclusion, a new understanding of Geographical Virtual Environments is reviewed and the critical questions that can determine the future prospects are addressed.*
Keywords. *Urban Models; Urban Planning and Design; GIS; Virtual Environments; Simulation.*

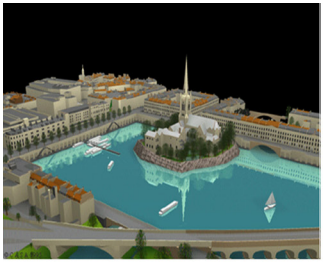
Introduction

Since the early visual simulations, computer mediated urban design and planning studies have shifted their focus from the sole representation of the built form, towards a holistic view of social, economical and environmental realities with a future prospect.

This shift can also be tracked through the contents. Early "city models" used to concentrate on aesthetic and formal representations whereas newer "urban models" cover the functional and social aspects of the urban space (Batty, 2006). Development of virtual reality environments played an important role in the initiation of "city models" whereas "urban models" were mostly made available by complex information systems.

In the age of 4D GIS applications, we can speak of a new generation: "open multilayered temporal urban models". These are automatically constructed through optical remote sensing data, linked with multilayered information featuring time as an attribute and highly available to the public through the web. "Kyoto Virtual Time-Space" project (Takase et al., 2004) is a clear example of such an urban model.

As distinguished memorable researcher Penttilä (1989) points out, a distinction between the subject and the content of modeling should be made for an in-depth study. Therefore, we will examine certain uses of urban models and technologies with a focus on (what) is being modeled, place (where), actors



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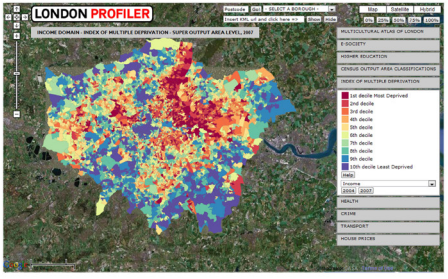

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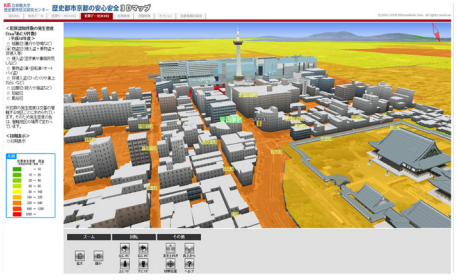

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Figure 1
a. City of Bath Model
b. Preliminary application of CommunityViz
c. The DIGCITY and 3D Graz Projects
d. Virtual London Project and GeoVUE
e. Kyoto Virtual Time-Space
f. Dynamic Urban Transition Model for Eindhoven
g. Virtual Environment Model for Transformation of Saint-Blaise, Paris.

(who), date (when), objectives (why) and approaches (how) adopted for design and development. With this vision, seven critical cases will be reviewed to bring up issues concerning the progress of virtual models, future trends and opportunities provided by geographic information systems featuring time as an attribute (4D GIS) and their integration with virtual reality technologies.

These critical cases employ a variety of means for mapping the history and the existing reality, creating forecasts through simulation and analysis of the possible impacts of the planned interventions. Initially supported by the metropolitan authorities, they are of different scales with different features and conducted with different aims and approaches, which makes them interesting in the context of this study (Figure 1):

- City of Bath Model (Day, 1994)
- The Commercial Model of Environmental Simu-

lation Center (2010) initially developed for New York City (Kwartler and Bernard, 2001)
- The DIGCITY and 3D Graz Projects (Dokonal et al., 2000) (Dokonal, 2008)
- Virtual London Project and GeoVUE (Batty et al., 1998; Hudson-Smith, 2009)
- Kyoto Virtual Time-Space (Takase et al., 2004) (Yano et al., 2004).
- The Urban Transition Model for Eindhoven (de Vries, 2009)
- Virtual Environment Model for Transformation of Saint-Blaise, Paris (2010)[5]

Case 1. VRML Visualizations and Experimental Interactions: *City of Bath Project*

The City of Bath Model (Day, 1994) is an excellent case of a "city model", as described in the introduction. It was initiated at the Centre for Advanced Studies in Architecture (CASA) at the University of Bath. It was implemented using virtual reality markup language (VRML). The project included aerial photographs and was intended to be used for volumetric studies and alternative development projects.

City of Bath Project initially focused on **"development control" through the visualization of planning alternatives** for the city (Day, 1994). With the advancement of the project, the researchers started to explore the use of VRML models in urban planning and developed functional interfaces specifically aimed at lay people (Bourdakis and Day, 1997).

One of the reasons to choose City of Bath Project as a critical case is that it clearly represents the zeitgeist of 1990s. The focus was on the successive visualization and delivery of aesthetical-formal aspects of design alternatives and increasing the usability of user interfaces. Although public participation was clearly addressed as one of the major objectives of the project, city models were not widely accessible over the internet by lay people due to technical restrictions such as bandwidth and limited public awareness. In order to overcome these issues, annual events were held by the researchers during the Bath Festival and local people were invited to make proposals (Bourdakis and Day, 1997).

City of Bath Project was definitely ahead of its time. The developed city model was used in other different applications like city growth management (Bulmer, 2001). The study is important because it is one of the earliest examples demonstrating the potentials of informative, accessible and interactive virtual models in urban planning.

Case 2. Software Supported Community Visioning: *CommunityViz and ESC New York*

The second case study is rooted in efforts of Environmental Simulation Center (ESC) to create a GIS-based model of Lower Manhattan, New York in 1995.

ESC was founded at the new School for Social Research in 1991 and transformed into a one-of-its-kind independent non-profit laboratory.

In collaboration with PricewaterhouseCoopers Consulting and Multigen-Paradigm, ESC has developed an original participatory decision making process based on **"community visioning"** in which local people were invited to a software supported town hall workshop for grass-roots involvement in policy-making. This study led to the design of CommunityViz, one of the first GIS-based planning and design decision support software (Kwartler and Bernard, 2001).

According to Kwartler (1998), this approach is a reaction to "over determined topological-based tower-in-the-park zoning regulations of 1961 for Manhattan" and represents a paradigm shift from urban land regulation to the urban land management through "zoning and growth management integrating a performance, feedback, and thresholds technique with the satisficing approach".

The major objective of community visioning is to establish a consensus in the community rather than creating an urban plan (Holtzman, 2006). In this context, it won't be wrong to state that the digital tools

and media were specifically utilized for **value-based requirement modeling and evaluation.**

In order to accomplish a consensus, ESC claims to provide a framework for small, incremental decision making; an empty shell with no data or formulas (Kwartler, 2001). The performance indicators are formulated and weighted by local people and entered into the system to reflect the community's values and sense of identity [1].

CommunityViz is a unique effort to develop a medium that can combine virtual reality with scenario design, impact analyzes, and policy simulation. It represents a successful collaboration scenario between leading private companies, government and non-profit organizations.

While developing CommunityViz, ESC **was not financially dependent on government research resources**. It is a clear example of how independent research institutions can develop serious applications with generous funding of operating family foundations.

Case 3. Integration of City Modeling Practices with Urban and Architectural Design Education: *DIGCITY Graz Project*

DIGCITY Graz Project is an ambitious academic initiative led by Wolfgang Dokonal, Bob Martens and Reinhard Ploesch of Graz University of Technology. It was aimed at the integration of city modeling practices with urban and architectural design education. Although the project did not completely reach its goal to create a complete city model, its contributions to education was prosperous (Dokonal et al., 2000).

At the basic level, DIGCITY illustrates an effective way of teaching students city modeling. Moreover, while making models, students can develop a deeper understanding about their living environment. In depth, researchers define a collectively achievable benchmark, which is a successful strategy for motivating the students to work together in a harmonious framework. In this context, DIGCITY Graz Project can be interpreted as an early experiment for **"studentsourcing": managing and channeling atomic outcomes of architectural and urban design education to reach certain goals**. The authors believe this approach may definitely lead to an improved curriculum.

In 2003, the workflow of DIGCITY Project and further experiences was used for the development of new routines, which led to the generation of a more serious city model for City of Graz. This work was undertaken by a private business offspring of Graz University of Technology, Institute for Computer Graphics and Vision (Dokonal, 2008).

DIGCITY Graz Project is a successful attempt that questions contemporary architectural and urban design education, offering a conceptual structure that can be improved and applied in the light of current web-based technologies.

Case 4. Neogeography: Virtual London Phase II and GeoVUE

Virtual London Project is a large scale research project realized at the Centre for Advanced Spatial Analysis (CASA) at University College London. It was funded by Greater London Authority and other private-governmental organizations. The project was initiated to assist the Woodberry Down and Kings Cross area regeneration projects (Hudson-Smith, 2003).

The initial aim of Virtual London was to develop a prototype application interacting with a GIS base that can incorporate different media, in particular, panoramic imagery as well as real-time photorealistic renderings. The entire London area within the M25 Orbital Road was modeled using Ordinance Data Master Map and InfoTerra height data.

This model was used in applications like web-based 3D air pollution maps and water level rise simulations. Unfortunately, it was never made publicly available due to copyright and ownership restrictions.

In its last four years, the project shifted its focus

towards the exploration of contemporary web applications as a social space and mapping of location-based and social information, in other words, **"Neo-geography" as initially defined by Di- Ann Eisnor** [2]**.** Geospatial data is distributed to external users through Google Earth and Maps creating a "mirror world" (Hudson-Smith et al., 2009).

Following the crowdsourcing trends, CASA has developed and distributed a toolset named Geographic Virtual Urban Environments (GeoVUE). This toolset includes Google Maps based applications like "GMap Creator" and YouTube inspired "MapTube" that allows users to upload and superpose vector-based attribute maps with existing maps, publish, store and combine them online.

Case 5. Heritage Conservation and Disaster Control: Kyoto VTS Project

This project was created by Ritsumeikan University and Research Center for Disaster Reduction (Yano et al., 2004).

Japan has a successful history in developing information systems. Models of all major cities have already been automatically generated using LIDAR data by the end of 2002 (Takase et al., 2004). Kyoto City stands out as one of the few cities that have survived the Second World War with little damage and holds 17 World Heritage Sites registered by UNESCO. In relation to these facts, the system specifically implemented for Kyoto is developed as a 4D web-based GIS **examining the possible effects of disaster** on the built environment. It allows a variety of interactions, including an advanced attribute query through the 3D models.

Besides the disaster risk zones, it displays information about crime data, storage spaces, hospitals and other critical facilities related to disaster management. Furthermore, the same framework was also used to **visualize the historical development** of the city.

The model is effective at the technical level and allows a high level of interactivity and seamless real time visualizations [3]. The motivations and objectives of this project are closely linked to the specific problems related to the high population density and complex nature of the urban agglomeration as well as cultural values highly respecting the historical heritage.

Case 6. Dynamic Transition Planning: Eindhoven Model

This model was initiated by Bauke De Vries, Joran Jessurn and Gaby S. Rasters, for the Municipality of Eindhoven department of Civil Development for the design of a GIS- based instrument for dynamic visualization of urban area transitions. The aims of the project were dynamic representation and discussion of new plans and decision making support on different scenarios (de Vries et al., 2009).

The project involves dynamic modeling, visualization and **conversion of urban development plans into transition scenarios** (de Vries et al., 2009).

The researchers created a well-defined data structure for district plans and an XML development schema which can be visualized using Google Earth. In this model, the timeline function of Google Earth is used to control the date and state of change. Functions and developments are represented with icons and roll-over explanations. Transitions related to the location of the buildings or functions are shown with interactive arches. By this way, changes can be visually observed and explored easily.

This model is a novel idea, which involves *location-based concept mapping*. It demonstrates the potentials of four dimensional GIS for visualizing concepts.

In conclusion, Eindhoven Model is an outstanding attempt to extend the use of GIS technologies in urban design and planning practices, created by researchers who are apparently well informed about latest technologies and urban development.

Case 7. Virtual Environment Model for Transformation of Saint-Blaise, Paris

In 2007, City of Paris has prepared a Metropolitan Urban Renewal Plan and determined eleven priority zones for development. The transformation of Saint-Blaise is one of these development areas.

Specifically for Saint-Blaise, City of Paris created a virtual environment model in corporation with Ligne2 Agency and the Arene Center for community planning and participation, aiming the improvement of the living quality of residents and meeting the principles of **sustainable development** as defined in Rio Declaration on Environment and Development in 1992 [4].

Certain principles are clearly indicated by City of Paris as a reference: participation, solidarity (reducing inequalities), precautionary management (considering long term environmental costs), transversality (creating synergies between territories) and responsibility (environmental action). Based on these values, a truly photorealistic model of Saint-Blaise was prepared and made available to the citizens [5].

The innovative side of the Saint-Blaise model is the strategy it employs for successfully integrating an urban development project at master plan level into a photorealistic model. It allows the citizens to see the proposed function and exact location of every specific intervention, get information from agent avatars and comment on the proposal. The downside of Saint-Blaise model is that it is an isolated stand-alone application. Such a model can be more effective when integrated into a GIS-based framework, facilitating numerous development projects.

Elaboration: issues concerning the progress of virtual models, trends and opportunities

In all of the cases, researchers brought together various strategies, methods or theories to develop their propositions, which are composed of different interrelated layers and levels such as data models, process models as well as environment models (referring to the medium) (Table 1). The interrelated conditions or circumstances that form the setting for these models also defined their characteristics.

Therefore, the authors would like to stress the importance of the **context sensitivity** in the development of city models. Researchers' individual approaches, focus areas, needs and geographies of the cities and availability of resources were the major factors determining the nature of the final products, which apparently change in time.

The case of Urban Transition Model for Eindhoven shows that the design of city and virtual environment models involves learning, questioning and integrating these models with the existing urban planning practices and defining relationships between related parties, city authorities, NGOs, public and private organizations.

Considering the frame of our analysis, it is important to conclude **that city and virtual environment models are never finished products**. They are under continuous development and they constantly evolve. Virtual London Project clearly illustrates that these models should be conceived and designed as **dynamic, flexible and sustainable** entities transforming with the urban planning approaches and related technologies.

In this context, it is not surprising to see that many contemporary research studies for/of virtual environments utilize web-based crowdsourcing applications like Google Earth as a reference point. The enhanced availability and functionalities of these software enable sustainability while LIDAR/Aerial imagery based and automatically generated city models bring up-to-date data to the researchers. Besides Google's 3D Cities program which currently includes nearly 90 cities in progress, commercial companies like GTA Geoinformatics, Cybercity 3D, C3 and Skape are delivering up to 900 cities in high LOD photo-textured formats.

In conditions where photo realistic experience of future developments is not essential -such as disaster management- generative modeling can be an

Table 1
Comparison of critical city modeling cases in terms of their context.

Model (and Where)	Who &When	What	Focus/Approach
City of Bath Model	Day, 1994	City Model	Visualization and Exploring Interactions
CommunityViz (initially developed for New York City)	Kwartler and Bernard, 2001	City Model & Software (GIS Based)	Community Visioning Urban Land Management
DIGCITY Graz Project	Dokonal et al., 2000	City Model	Educational Integration
Virtual London & Extended Applications	Batty et al, 2003;2009	Urban Model+ Web App. (neoGIS Based)	Neogeography
Kyoto Virtual Time-Space	Takase et al., 2006	Urban Model+ Web App. (GIS Based)	Disaster Control Heritage Conservation
The Urban Transition Model for Eindhoven	de Vries et al., 2009	Dynamic Data Structure (GIS Based)	Transition Planning
VE Model for Transformation of Saint-Blaise, Paris	City of Paris, Ligne2 & Arene Center, 2010 [5]	Partial Urban Model+Web App.	Sustainable Development

effective simulation tool. Kyoto Virtual Time Space is a typical example of this type of city modeling approaches. The project proves that, using this method, complete high performance city models, including historical monuments, can be created.

On the other hand, Saint-Blaise Model demonstrates that carefully planned and geographically limited virtual environments with photo realistic textures can provide enhanced pedestrian navigation and experience, a critical decision making tool for projects aiming the improvement of the living quality of residents.

Terrestrial photos, ambient sounds and **possibility of A2A (avatar to avatar)** communication creates a stimulating medium that can promote participation to urban design and planning processes.

The case of CommunityViz, in contrary, stresses the **importance of F2F (face to face)** communication in urban design and planning. Physical existence of local citizens in grass-roots town hall meetings can increase the sense of responsibility and sense of community. CommunityViz follows an open democratic model in the discussion of urban development projects while the software is truly proprietary and closed to user intervention. This issue can limit the development and competitiveness of this software.

Conclusions and Future Prospects

The case studies represent the high level of variation in city and environment modeling strategies during the last 15 years. They were selected on their additional ambition to integrate virtual models with urban design and planning decision making processes and academic education. Although all projects initially aim the development of real urban environments through the use of virtual ones, the outcomes are very different.

Local context is one of the most critical dimensions of urban design and planning practices, which also shapes the city modeling projects. Through the case studies, we demonstrated that the virtual environments and city models were directly linked to social, cultural, economical and ecological significance of the surrounding environments.

Therefore, learning, questioning and integrating with the existing urban planning practices, and defining possible roles of related parties in the decision making processes are crucial for the design of city and virtual environment models. Solely creating a photorealistic representation of a city does not provide sufficient solutions for any of these tasks.

Besides the local context, the Kyoto and London cases were affected by the captivating new culture that is rapidly emerging through Wikinomics, Crowdsourcing, Artificial Artificial Intelligence, armed with Web 2.0, mashups and smart gadgets which open up new research areas in social science such as netnography and real-time archeology.

Neogeographical studies similarly rose from this hype and have started to transform the traditional understandings of geography (Haklay et al, 2008). This kind of research focuses more on improving delivery methods and designing useful tools especially for lay people, integrating with the existing "killer applications".

Neogeography illustrates a significant shift from scientific standards to loosely defined norms by focusing on individual "human" aspects, subjectifying methodologies and blurring the distance between the researchers and the researched. Virtual urban environments become a common subjective medium for sharing instant personal information for the masses that create a sheer amount of location-based and tagged data, using a variety of digital tools.

In this sense, neogeographical "place" is not far from Lefebvre's (2004) depiction of "temporalized place" and "localized time" where the relation between space and time is constructed through the daily rhythm of the city. Many other links can be made with contemporary theories such as "everyday urbanism", similarly idolizing the diversity, ephemerality and complexity of ordinary urban life.

The topics that are discussed above lead to an understanding of Neogeographical Virtual Environments through which **the distance between large scale city modeling and area-focused abstract modeling rapidly decrease and the concepts of virtual environments and GIS converge.**

In this contemporary societal context, urban development becomes a reflective process between the real city and the virtual city (or geographic web). Place-based multimodal conversation between the coexistent "netizens" becomes the focus and medium itself, creating a network of geolocated subjective information.

Openness, decentralization, subjectivity and creativity rise as globally agreed values while assets of hectic production and consumption of real time information still stays a subject of discussion.

Future studies still need to answer many questions that neogeography does not clearly address: How do these new developments influence the relationship between related parties in urban design and planning? How can the sheer amount of unstructured subjective data be used to improve decision making? How can state of the art application hybrids be integrated into these processes?

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