

# 3-DIMENSIONAL VIRTUAL REALITY IN URBAN MANAGEMENT

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**KEYWORDS:** 3-Dimensional, Internet, Virtual Reality, Urban Model, Immersive Virtual Environments, Virtual City, Computer-Aided-Design (CAD)

## ABSTRACT:

The emergence of virtual reality and related tools is providing the fundamental infrastructure to begin building virtual cities which can provide an interactive simulation and analysis environment for planning and management of urban places. The virtual city will provide urban managers with a computer environment to interface with the multitude of complex physical and social data needed to plan and manage cities, along with necessary tools to explore and analyse that data in meaningful and intuitive ways. This paper looks at the applications of 3D Virtual reality (VR) in Urban management, its limitations and the future of 3D VR in urban management.

## 1. INTRODUCTION

Neighbourhoods, cities and regions are complex phenomena. The way planners and urban designers think about and communicate their ideas about urban problems and their solutions is strongly, although not exclusively, visual. Visualisation of urban planning and urban design is based on three premises (Dodge et al., 1998):

- To understand nearly any subject of consequence it is necessary to consider it from multiple viewpoints, using a variety of information;
- Understanding complex information about urban planning and urban design may be greatly extended if the information is visualised;
- Visualisation aids in communicating with others.

Communication and Visualisation is at the heart of the planning system, the map and plan in two-dimensional form has been the norm, although extensions to the third dimension are important through urban design, which acts as the interface between planning and architecture. Other visual media such as photographs and statistical presentations through charts of various kinds also supplement the way such communication takes place.

The potential of visualisation in the planning and design of the built environment is very significant. The ability to represent, model and evaluate changes to the built environment on the computer desktop and over the Internet offers potential to enhance the planning and design process; and also help communicate ideas and developments to the public at large.

The traditional approach is to display images and information within a two dimensional (2D) framework, whereby real world phenomenon are projected in Euclidean space in either vector or raster formats (Tomlin, 1990). With 2-Dimensional

presentations, layers of data sets are needed to fully described an urban set-up. These layers become so complex and only professionals can fully manipulate and get information for the layers. The ordinary man will thus be sidelined by such a system. Of late, researchers have been exploring the use of 3D VR Systems to overcome the limitations of 2-D Systems.

## 2. APPLICATIONS OF 3D VIRTUAL REALITY IN URBAN MANAGEMENT

Outlined below are some of the application areas for 3D Virtual Reality:

- Planners can now model urban environments in three-dimensional electronic space, using Computer-Aided-Design(CAD) or advanced visualisation techniques (Levy, 1995). Virtual reality models of entire cities, are possible: a model of Bath, produced by researchers from CAD models, is one example of such a large-scale urban model (Bourdakis, 1997). Virtual models can be viewed from different viewpoints: both bird's eye views which quickly give survey information about the city, and eye-level perspectives from the vantage point of pedestrians and motorists can be generated.

Utilising VR, planners can map on the site and its surroundings census data, land use and behavioural diagrams, climate and pollution simulations and other data enhancing experts assessment and most importantly reducing the need for site familiarity.

Furthermore, planners can use virtual reality models to assess the impact of new housing schemes in relation to transportation patterns, and access to schools, shopping facilities, parks and other amenities.

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- Computers have been used in architecture for almost three decades (Mitchell, 1996), although adoption by practitioners has been slow mainly due to software and hardware limitations. Over the last decade, the expansion of high resolution input and output devices and the vast increase in raw computing power, led to the creation of efficient CAD packages and thus the construction of two-dimensional (2D) as well as three-dimensional (3D) computer models. Subsequently, urban 3D computer models were developed and a series of, well documented by now, problems tackled (Bourdakis, 1996, Bourdakis et al., 1997). However, the introduction of interactivity and real time manipulation of urban CAD models has proved to be a long and, to a great extent, ongoing process.
- It can be argued that 3D VR enables more substantial public participation, making information more accessible and comprehensible (Hall, 1996). It should be noted that the 2D architectural plans or maps are quite difficult to understand for non-professionals, hence the drive for 3D VR Systems.
- In seeking to provide good quality new residential development for the housing developers, the ability to appraise proposed developments before construction will be increasingly important. Virtual reality (VR) enables environments to be created that can be entered into and interacted with directly, greatly facilitating this process of visualising, evaluating and communicating new design ideas. The kind of homes required in the future may be quite different, and virtual reality could be used to present and evaluate innovative solutions to housing for the 21st century.
- Virtual reality could be a useful tool for evaluating the quality of residential development. Its use in the housing industry becomes feasible as some developers are moving from a traditional paper based approach to a use of new technologies and the Internet. Ongoing research at Loughborough University is focused on housing developers' use of virtual reality for marketing and collaboration with planners.
- 3D VR is gaining ground in mapping. Traditional presentation of maps has been based on 2D systems. The 2D maps are easy to comprehend when the amount of data presented is reasonably less, but as the need for detail grows, the 2D map becomes difficult to understand.
- 3D VR systems are slowly finding applications in cadastral systems. In areas with an intensive use of Land (e.g. urban set-ups), there is a growing interest in using space under and above the surface (Oosterom et al., 2001). The Municipality of Oslo established in 1987 3D VR system whereby 3D objects could be registered as real property both in the cadastral and title register (Valstad, 2001).
- Lastly, 3D VR could be handy in utilities management. Most Urban set-ups have a maze of utility lines running underneath them. Tracking these in a 2D set up would not give a realistic picture of their positions relative to the many foundations of buildings. 2D presentations are incapacitated when it comes to slope representations. New utility lines can be easily introduced in a simulation exercises in 3D VR system without the danger of "hitting" into other lines or violating the construction regulations.

### 3. VR URBAN MODELS

The success of "Virtual Urban Design" can be measured in the following ways:

- It's ability to convince the client (i.e. the public, regulating bodies, and lobby groups), that the proposed urban guidelines can be successfully implemented.
- It's ability to convince urban designers that models and simulations are realistic and accurate, and that VR can be used as a powerful and useful tool in urban design.

To fully abstract reality into the "Virtual Urban Design", 3D data models should be employed. Research has provided a number of 3D data models among which include ; Winged-edge data structure (see Baumgart, 2002), 3D Formal Structure (see Molenaar, 1998), and many more. From these data models, A number of 3D VR models have been developed and below, a brief description of some is provided.

In Berlin, an urban development and architecture unit created the *CyberCity Berlin* and the *Planwerk Berlin* (a 3D masterplan for the city) employing new media in town planning. In the UK, one of the first comprehensive urban models was that of Glasgow constructed by ABACUS at the Strathclyde University in the mid 80s. Recently, the University College of London (UCL) Department of Geography has embarked on a large-scale project researching on ways of producing built environments using VR systems focusing on London. Approaching the topic from a historic viewpoint, Strathclyde University has subsequently constructed a model of Edinburgh Old Town (Grant, 1993). On the other hand, a number of companies have addressed the problem of 3D urban modelling for commercial applications, tourism and entertainment (Virtual Soma - the first virtual city on the Internet in August 1995, Bigbook, Virtual Derby, etc.).

The model of London's West End is of lower level of detail and was initially used for cellular telephone transmitter signal propagation experiments by British Telecom (BT). Freely available WWW resources have been linked to the 3D model, creating a hyperlinked, user upgradeable, city database (Bourdakis, 1996). Visitor specific aids (accommodation, entertainment, services, etc) as well as some engineering focused information (underground servicing channels etc) are currently linked to this model. The idea being that over the next decade, most city related information (as more or less every type of information) will be available on computers and, judging from the expansion of the internet over the last decade (Negroponte, 1995), available on the WWW in one form or another.

### 4. LIMITATIONS OF VR

Successful Virtual Environments have been mainly developed for computer-related tasks as well as mechanical engineering design. They are feasible but the software currently available is not suitable for design and planning at an urban scale. Undoubtedly, new solutions will appear soon, but caution should be exercised to avoid creating more problems instead of solving current ones.

Immersive Virtual Environments have proved in various occasions to be quite problematic - a lot of resources are needed

to make them work, limiting the usefulness of the overall project. It is becoming increasingly feasible but as Byrne (1996) argues, interactivity is still the significant factor, immersiveness is often disorienting, problematic and from his experiments not significant. Training, virtual world design, aesthetics, level of detail, assessment and low level of hardware resolution are among the possible reasons for immersion's lack of significance. However, a carefully designed interactive Virtual Environment can be much more practical and useful. Nevertheless, large screen displays similar to the various Reality Centres, are ideal - if not outside the budget of even the wealthiest city council.

Resources is a factor of paramount importance and mainly responsible for the fact that there are practically no successful applications of highly detailed VR in city models.

Although 3D Virtual Systems have been developed, one area of major concern is the ability of data models to fully represent all complex forms of the urban set-up and the voluminous data involved. The speed of processing this data is an issue closely related to the amount of data that can be stored by the hardware based on the model used.

## 5. THE FUTURE OF VR URBAN MANAGEMENT

Virtual reality has the potential to assist housing developers evaluate and market new housing schemes. It can be used to describe residential development both on its own and in conjunction with other new media and the Internet

Many housing developers now have web-sites and in the future some housing developers may have increasingly computer-based methods of working, perhaps using virtual reality for design, as well as for collaboration with planners and for marketing properties.

Virtual reality models can be used by planners to assess proposed new housing schemes in the urban context, as they can be imported into larger city models. The use of virtual reality could provide benefits in terms of improving the quality of the new housing and interesting house-buyers in quality housing. Further work is needed to analyse the potential for virtual reality to assist planners and housing developers to work together using a shared virtual model, and its use for marketing of efficient housing.

Compatibility of the urban VR computer models built in different areas of the country or even different countries will be an issue. Standards of VR urban model creation should be developed and employed.

For 3D cadastral systems, most of the existing laws have no provision for 3D properties and as a result, they are only limited to undergraduate 3D objects and 2D surface features. A deliberate effort has to be made by authorities to incorporate 3D objects into property statutes.

The introduction of computers was the first step, now that interactive planning tools are becoming feasible and even available (although still mainly at a research level), the natural development is to embark into VR design tools that will eventually be used by everyone and not only the professionals.

## 6. CONCLUSIONS

As it often happens when a new technology is introduced, VR has been viewed as panacea for various research fields that seek to manipulate information visually. It has been applied and argued as being the ultimate solution to problems ranging from training and teaching to entertainment, information management and data mapping, medical and chemical visualisation, etc. Although not entirely true in all fields, VR, when used carefully and sensibly, seems to facilitate research and practice in urban management. However, care should be taken and thus further research is needed on the implications of its use in different stages of the negotiation/design process.

VR facilitates freedom of movement within the scheme and the simulation of movement at ground level minimises the dangers and misconceptions of bird's eye view perspectives that scale models and computer generated images very often suffer from. Presentation and comparison of alternative schemes is simplified and building elements can be selected and investigated in greater detail if needed. Most importantly, VR enhances communication channels, offering immediate feedback by limiting the need for the design - export - render cycle found on conventional approaches.

## REFERENCES

- Baumgart, B.G., 2002. The Winged-Edge Data Structure. <http://www.cs.mtu.edu/~shene/COURSES/cs3621/NOTES/model/winged-e.html> (accessed 8 March 2002).
- Bourdakis, V., 1996. *From CAAD to VRML: London Case Study*. Proc. 3<sup>rd</sup> UK VRSIG Conference, De Montfort University.
- Bourdakis, V., 1997. The Future of VRML on Large Urban Models. *Proceedings of VR-SIG'97*, pp. 55-61.
- Bourdakis, V. and Day, A., 1997. *The VRML Model of the City of Bath*. Proc. Sixth International Europa Conference, Europa Productions.
- Byrne, C., 1996. *Water on Tap: The Use of Virtual Reality as an Educational Tool*. Doctoral Dissertation. <http://www.hitl.washington.edu/publications/dissertations/Byrne/>
- Dodge, M., Doyle, S., Smith, A. and Fleetwood, S., 1998. *Towards The Virtual City: VR & Internet GIS for Urban Planning*. Virtual Reality and Geographical Information Systems, Birkbeck College, London.
- Grant, P.M., 1993. *Urban GIS – the application of information technologies to urban management*. In: *Informing Technologies for construction, civil engineering and transport*. Powell, J.A. and Day, R. (eds.), Brunel University, Uxbridge.
- Hall, A.C., 1996. *Design Control; Towards a new approach*. Butterworth Architecture, Oxford.
- Isdale, J., 1999. What Is Virtual Reality-A Web Based introduction. <http://www.isdale.com/jerry/VR/WhatIsVR.html> (accessed 8 March 2002)

Levy, R.M., 1995. Visualisation of Urban Alternatives. *Environment and Planning B: Planning and Design*, Vol. 22, pp. 343-358.

Mitchell, W.J., 1996. *City of Bits*. MIT Press.

Molenaar, M., 1998. An introduction to the theory of spatial object modeling. Taylor & Francis, London.

Negroponte, N., 1995. *Being Digital*. Hodder and Stoughton, London.

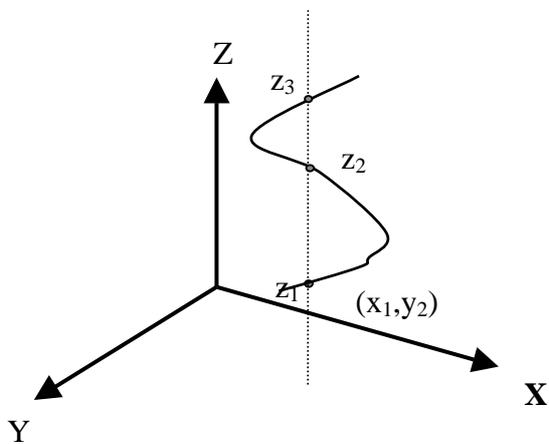
Oosterom, P.J.M., Stoter, J.E. and Fendel, E.M., 2001. Registration of properties in strata. Proc. International Workshop "3D Cadastres", Delft.

Raper, J., 2000. Multidimensional geographic information science. Taylor & Francis, London.

Tomlin, C. D., 1990. Geographic information systems and cartographic modelling. Prentice-Hall, New Jersey.

Valstad, T., 2001. The Oslo Method: A Practical Approach to Register 3D Properties. In: Registration of properties in strata, Oosterom, P.J.M., Stoter, J.E. and Fendel, E.M. (Eds.), Proc. International Workshop on 3D Cadastres, Delft, pp. 1-7.

#### APPENDIX A. DEFINITIONS



3D Modelling (Raper, 2000): 3D modelling is the ability to assign up to three z(height) values to a point (see figure above).

Virtual Reality (Isdale, 1999): "Virtual Reality is a way for humans to visualise, manipulate and interact with computers and complex data".