

## USING VIRTUAL REALITY TECHNOLOGY TO FACILITATE WEB-BASED PUBLIC PARTICIPATION

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**Abstract:** Virtual reality as an advanced visualisation technology is used in many aspects of urban design and management to assist the various stakeholders' better understanding of the urban environment. This paper is based on an EPSRC funded research project – "Web-Based Participation for Campus-Scale

Project Design: The West Cambridge Site”, which aims to facilitate web-based participatory consultation to allow staff, students and local residents to learn about, and debate, planning and building proposals by Cambridge University. Interactive 3D virtual reality models were created of a number of proposed urban development projects in Cambridge and published on the University web site along with mechanisms for surveying users’ opinions of the proposals. These were linked to relational databases on the web server for recording survey responses. Care was taken to provide the participants with a friendly interface and interactive functions to easily navigate the model and accurately understand the issues involved. This paper starts with reviewing the theory and practice of implementing virtual reality visualisation for public participation in urban design. The technical details of creating the 3D virtual reality models, merging them into the web site and linking objects in the virtual reality model with databases, are described. Finally the advantages of, and the barriers to, this kind of virtual reality application are addressed.

**Key Words:** Urban Planning, Web-based Public Participation, Virtual Reality Modelling Language (VRML)

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## 1. Introduction

The involvement of communities becomes the way for residents to re-own their space, and support the process of rehabilitation. This support is fundamental to make the urban renewal more effective (Cerreta and Torre, 2000). By the end of last century, about one-tenth of the nation's population was estimated to have benefited from public participation events in US (Wates, 1996). The common objectives of public involvement in local development are addressed as information exchange, discovering common needs, resolving conflicts and supplement design and planning, and finally achieving the widely-accepted development scenarios (Sanoff, 2000).

Conventionally, organizing the participation forums and events is the typical means to be adopted in public participation activities. And many of the popular participation methods, such as Community Acting Planning (Microplanning); Planning for Real, Goal Oriented (GOPP), Urban Community Assistance Team (UCAT) are based on people's attendances of these forums and events (Hamidi and Goethert, 1997). The efficiency of these forums and events strongly relies on the physical attendance of the participants usually at certain locations and times. However, the studies from the practical participation cases show that the limitations of the times, locations and spaces pre-set for participation events and forums restrict many identified participants' attendance, especially elders, children and the disabled. Another problem confronted by people in the conventional participation forums is that the public, especially the lay people in design and planning, have difficulty to understand the presentation materials prepared by professional designers and planners, such as contour maps, plan drawings and so on. Therefore, a number of professionals have to be employed as the facilitators in these participation forums to interpret the professional planning and design materials to the participants. These major barriers determine that the conventional participation events could only serve a certain number of participants, who may represent various groups of people with various interests (Davies, 2001). It is the so-called representative participation. However, in order to shift the representative participation to "grass-root" participation, participation organizations should involve all of the people, whose interests may be impacted by the proposed environment changes, in decision-making processes of the whole lifecycle of an environmental development project.

Since the 1990s, with the dramatic decrease in the price and increase of the power of personal computers, PCs have become essential items of each householder as paper working machines or entertainment facilities. At the same time, the Internet has become increasing popular in people's lives as a convenient and fast means of communication and information exchange due to the conception and implementation of the World Wide Web (WWW). According to a survey conducted by Network Wizards in Finland in 2001, almost every

household of 5.5 million residents in Finland has a computer and nearly half of the households are connected to the Internet. This illustrates that the Internet possesses the great advantages to be adopted as a means in public participation. It could be the solutions to the barriers encountered in the conventional participation forums. Any people who can access to the Internet can join the debates and discussions about the environmental changes in any times and at any places. Moreover, the PCs with powerful graphic processing card also enable participants to view the high quality images on their screen, which could be both 2D and 3D visual products. Based on these hardware availabilities and improvements, many research pioneers around the world have been exploring the ways to effectively implement the Internet and web-based visualisation technologies in the public participation of urban planning and design (Shieffer, 1992; Batty, *et. al*,1998;). The implementation of the Internet has changed the way in which planning decisions are made and the way in which the public are interactively involved in the processes of planning and design decision-making (Cohen, 2000).

Accordingly, this research project was funded by the British Engineering and Physics Science Research Council (EPSRC) and conducted by the CADLab of the Martin Centre, the Department of Architecture at Cambridge University. It aims to develop a web site with appropriate visual representation approaches to present the master planning information of the West Cambridge site so that it can promote the public's awareness of the environmental changes on the university campus. This project also aims to involve the staff and students of the University in expressing their opinions on this environmental development (Ruffle and Richens, 2001). Various visualisation techniques have been trailed and adopted in this project in order to improve people's understanding of professional design. This paper will focuses on the implementation of VRML visualisation techniques and the development of an integrated online virtual reality participation system. Both positive and negative experiences are drawn through this research. And some solutions to improve this virtual reality visualisation technology have also been given.

## **2. Background**

As described earlier, the overall target of this project is the creation of the University of Cambridge Planning and Building Web site, which aims to present to the members of the University the planning and design information regarding a series of building projects. It initially focused on two teaching sites of the University – the Sidgwick Site and the 65 ha West Cambridge Site. Some impressive buildings are located on these sites, such as the Microsoft Research Building, Computer Laboratory of Cambridge University, and so on. Over a hundred pages of information, news, maps, plans and other material about a series of the Cambridge University's building design and planning programmes have been published on this web site over the period of three years. And some on-line consultation functions are also set up for the certain projects and issues regarding the plans and designs (Ruffle, 2002). The web site is still running and

updated today. Various visualisation approaches have been experimented or adopted in this project to represent the planning and design information.

Through literature search, it can be found that Web-based participations have been widely adopted in the campus planning projects by many universities in US, including the master plan of the Seattle Campus of Washington University (<http://www.washington.edu/community/cmp/cmp.html>), the University of Chicago campus master plan (<http://www.uchicago.edu/docs/mpsite/masterplan/index.html>), the university of Texas in Arlington ([http://www.uta.edu/master\\_plan/](http://www.uta.edu/master_plan/)). Most of these web sites focus on publishing the information and documents of master plans and other relevant building projects, and informing people some immediate influences caused by the building or infrastructure works. Although these web sites obviously made contribution to the people's awareness of these proposed environmental changes, some major weaknesses in term of public participation are addressed from studying these web sites. First, most of these web sites are only on purposes of achieving public's awareness, rather than consultation of the environmental changes. Secondly, most of these web sites just simply present the professional planning and design documents and drawings on the wet sites rather than using some other visual representations, especially 3D interactive visual representations. Therefore, this research applies the VR visualisation technology and other web site development technologies to targets on the solutions of these problems.

3D Virtual Reality technology has been recognized to possess the potential capacity of representing urban planning and design. 3D realistic and interactive models can enable the stakeholders and public participants to easily and accurately understand professional plans and designs. Actually, the public's understanding is a key factor to the success of a public participation in planning and design decision-making processes. Much research efforts have been made in this field so far. For instance, the Centre of Advanced Spatial Analysis at University London, have conducted a number of research projects regarding the implementation of 3D virtual reality visualisation technologies in the public participation of urban planning and design (Batty, *et. al*, 2000). In UK, many 3D virtual reality urban models created for public consultation in urban design, such as Bath models (Bourdakis & Day, 1997), Glasgow models (Ennis, *et. al*, 1999), can also demonstrate the researches in this field. A previous study was also conducted in the CADLab, which use 3D virtual realty models created in Quake II to consult with the stakeholders of the University Computer Laboratory design (Richens & Trinder, 1999).

### **3. The System Structure, Functionality and Interfaces**

As well known, the VR technology can be typically classified as immersive VR and non-immersive VR. The immersive VR is the kind of interactive visualisation techniques immersed with various VR equipments, such as Head Mount Display (HMD), CAVE, VR Workbench, and so on. Those VR equipments usually are very expensive and can only be manipulated by trained VR professionals. The

non-immersive VR is also called “Desktop” VR, which does not immerse any VR equipments except Desktop PCs to visual and control the VR visual products. Therefore, the Desktop VR is much suitable technology to be adopted in the web-based public participation, which aims to serve the general public who are just able to access the Internet from PCs.

Virtual Reality Modelling Language is the most popular desktop VR technique today, which is able to deliver real-time interactive 3D models with realistic texture over the Internet. In this project, VRML technique was adopted to create the 3D models, which represent the West Cambridge master plans. A creative approach to incorporate people’s navigations of the VRML models and their participation activities is also applied in this research project. The diagram below (Figure 1) shows the overall structure of this virtual reality participation system.

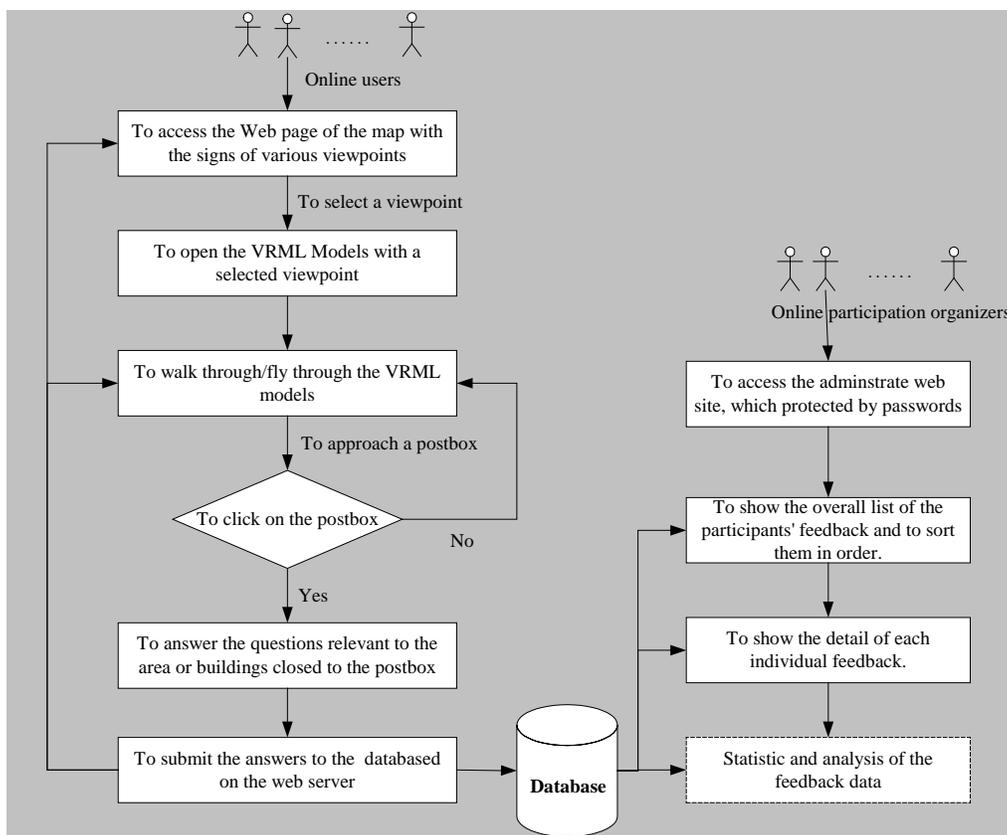


Figure 1 The overall structure of the virtual reality participation system

As described earlier, the online users of this project were members of the University. They therefore are supposed to be able to access the University network, which is usually 100 Mbps broadband Internet connection. In the left of Figure -1, online users firstly access the Web page of the virtual tour, which consists of the map of the planning site with the signs of camcorders and post-boxes. The clickable signs of camcorders indicate the different initial viewpoints of the VRML models, which enable users to quickly access the locations or facilities, which they want to go. Seven different starting viewpoints are pre-set in

the West Cambridge models. They can quickly lead users to the following seven important locations or facilities highlighted this master planning (Figure 2).

1. The main road to access this new campus.
2. The new car park for the West Cambridge campus
3. The Computer Laboratory Building
4. The Microsoft Building
5. The Marconi Building (now known as the CAPE Building).
6. The view toward the proposed East-Forum Buildings
7. The footpath leading to the City Centre of Cambridge.

The signs of the post-boxes indicate the question points, which strongly related to those seven locations on the site. For the users who view VRML model files at first time, they have to download and install a VRML viewer into their PCs. In this case, the Cortona VRML viewer developed by the Parallel Graphics is recommended by the web master. It is free to download. However, other VRML viewers, such as the Cosmos VRML viewer, can also be used to view the West Cambridge VRML models.

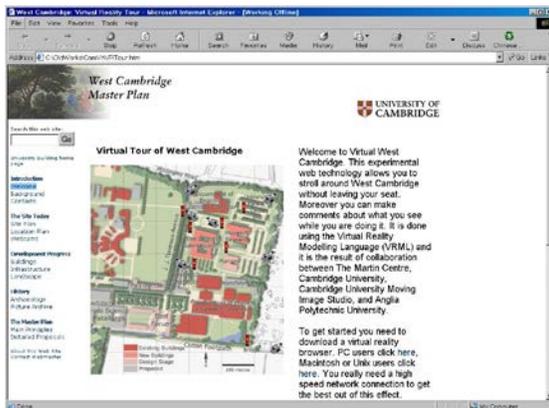


Figure - 2 The main web page of the virtual reality tour and questionnaire of the West Cambridge master planning

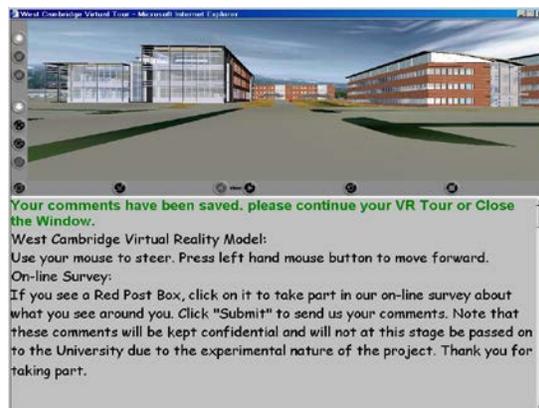


Figure - 3 The integrated interface of the VRML models with the questionnaire

Once a user clicks on a sign of the camcorder on the map (Figure 2), a new window with the 3D VRML models (Figure 3) will be loaded on his PC with the starting viewpoint he chooses. In Figure 3, the window is split into two parts. The up section is the VRML models with the navigating functions of the Cortona VRML viewer. The lower section is the text window, which contains the operating instruction and the questionnaires. The operating instruction gives users the brief instruction on how to use mouse to navigate the models. Users can simply move the mouse up or down to move forward or backward, and left or right to turn the viewpoint around. They can walk through or fly through anywhere on the planning site. Users can also change the parameters in the property set of the Cortona viewer to adjust the resolutions of the images and the navigating speeds. In this case, the Cortona VRML model viewer is set not to allow users to walk through the objects in the scenes, such as walls, windows and so on. This

simulates the situation in the real world. However, users can use the “fly through” function to cross wall, windows, and closed doors to get to the inside of a building. The certain details (main structures) of the inside spaces of the buildings are modelled in this project. This gives users an opportunity to view the outside environments from a viewpoint in various stories within a building. A detailed view of this West Cambridge models is shown in Figure 4. Online participants can see what the plan and building design exactly looks like in the virtual world before the construction of the planning and design is actually started. This 3D virtual environment obviously can enable people’s much better understanding than 2D planning drawings.



Figure 4 the detailed view of the West Cambridge VRML models

A creative approach to merge people’s navigation of the 3D VR models and their participation activities together is applied in this project. It is to set up a number of questioning points in the VR models, which are represented as the clickable post-boxes. By clicking on one of these post-boxes during their navigation of the models, online participants will be asked to fill a group of questions related to the scenes near to this post-box (Figure 5).

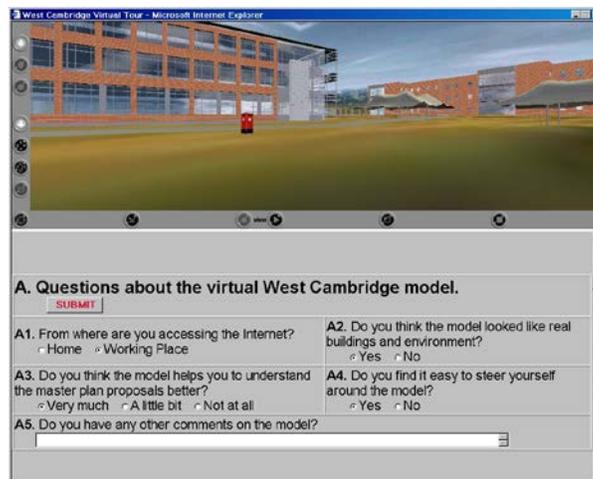


Figure 5 The VR view with the relevant questions

Once the questions have been filled, users can submit their answers to the database on the web server. The Microsoft Access database system is applied in

this application to store the feedback from online participants. Active Server Pages (ASP) technology is adopted to program the applets, which conduct the database operations, such as add or delete a record to a database table, query or sort the database records, and so on. Figure 6 below shows the records of the database table, which were collected from the online question survey in the period of the system test. In order to support the analysis of public participation feedback, some additional information are also collected or added in the database. For instance, ID is a unique code assigned to each record to ensure that each record is unique in the database table; the IP Address stores each user's IP address as they submit their answers. These IP addresses can be used to roughly identify users' locations or to tell if the user is in the University; the time can be used to analyse the distribution of the time, at which people access this web site.

ID	IPAddress	time	a1	a2	a3	a4	a5
1	169.254.41.5		Working Place	Yes	Very Much	Yes	
3	194.83.47.24		Working Place	Yes	Very Much	Yes	
4	194.83.47.24		Working Place	Yes	Very Much	Yes	
5	62.255.40.85		Working Place	No	Not at all	No	
6	194.83.47.20		Working Place	Yes	Very Much	Yes	
7	62.255.96.89	/2001 13:31:53	Working Place	Yes	Very Much	Yes	
8	169.254.38.120	/2001 14:02:04	Working Place	Yes	Very Much	Yes	
9	169.254.38.120	/2001 14:03:41	Working Place	Yes	Very Much	Yes	
10	169.254.38.120	/2001 14:03:52	Working Place	No	Very Much	Yes	
11	169.254.38.120	/2001 14:07:15	Working Place	Yes	Very Much	Yes	
12	169.254.38.120	/2001 14:11:03	Working Place	Yes	Very Much	Yes	
13	169.254.38.120	/2001 14:11:50	Working Place	Yes	Very Much	No	sdgsdgdgsdgsd
14	169.254.189.19	/2001 10:41:42	Working Place	No	a little bit	Yes	ghfhjghfhj
15	169.254.189.19	/2001 10:41:43	Working Place	No	a little bit	Yes	ghfhjghfhj

Figure 6 The structure of the database table and some sample recorders

#### 4. Discussion

This virtual reality participation system was not applied in practice in this project due to a number of reasons, mainly the delays in the East Forum development, which was initially supposed to be the case adopting this system. However, the broad discussions have been made among the project team and the various stakeholders involved in the master planning of the West Cambridge Site, such as the representatives of the Estate Management Department of the University, the planners and architects, the owners and users of each individual building, and so on. And a number of tests were also conducted by the research team to exam the usability and functionality of this system. Both positive and negative issues of this VR application have been addressed through these discussions and tests as follows:

In comparison of the other representation media, which are conventionally adopted in the representation of urban planning and architectural design, some advantages of virtual reality representation can be addressed as that the representation media of virtual reality technology is fundamentally far more effective to enhance the public's understanding of professional planning and design, than the conventional media, such a pictures or animation video clips,

which are either static or produced in the fix viewpoint traces. The VRML technique provides users with the full controls on the movement of viewpoints from any directions. The viewers of VRML models, such as Cortona, Blaxxun, Cosmo and so on, are free downloaded. This enables the VRML model more accessible to the general public without any extra costs.

The VR technology can also enable virtual reality models to have some reactions to the actions of user's navigation. This will make 3D virtual reality models more attractive and realistic. This can offer users the perception of playing a game. It can attract the interests of younger generation's participation.

The questioning functions merged with users' navigation of the VRML models provide users the convenience to answer these questions more easily and accurately, because the questions which users are requested to answer are strongly related to what users see in this case. However, in order to set up the appropriate questions and the targets of the online survey, it is crucial for the project managers, the master planners and the architects to work together closely.

On the other hand, some negative issues were also raised in the discussions:

#### **The size of the VRML model files**

The final size of this VRML file is about 6 MB; and the texture image files are about 3 MB. Such large size (10 MB in total) of the VRML models is obviously not suitable to the dial-up Internet users and even some broadband users outside the University network. However, this problem can be resolved or reduced through the modelling techniques and the displaying techniques. Firstly, the original CAD models were created according to the architectural drawings of these buildings. Consequently, the certain details of the interior structure have been made in these building models. Due to this project focusing on the urban environment planning issues, some of these interior details can therefore be simplified or deleted to reduce the final size of the model file. Secondly, the VR models of some buildings existing on the site can be modelled by Photogrammetry techniques, rather than creating physically geometric CAD models. Thirdly, the Level of Detail (LOD) methods and techniques may also be used to control partially displaying of the details of VR models on users terminals. This can reduce the problem of downloading the VR model files with large sizes.

#### **The quality of the images of the VR models**

The quality of the VR models is fundamentally determined by the resolutions of mapping texture images and the precision of the geometric mesh models. Although the increase of the resolutions of texture images and the precision of the CAD models can achieve the higher quality of the VR models, the balance between the sizes of the VR model files and the resolution of the VR models has to be comprehensively considered. Moreover, some VRML browsers, such as Cortona, can allow users to adjust the resolutions of VRML models. However, the increase of quality will also reduce the speeds of navigation. Therefore, the most

effective way to achieve higher quality of VRML models is to use more powerful computer and faster speed Internet connection.

### **The download and installation of the VRML browsers**

Some people in the discussions expressed their worries on the difficulties of users' downloading and installing of some VRML browsers, such as Cortona, Blaxxun, Cosmo. This could be a barrier to the people, who have not much experience and knowledge of using computers, and may bring some inconvenience to online users to access the VR models. This may be improved through directly linking to these browsers' downloaded addresses and providing people with more clear and detailed instructions of the installations of these applets. However, due to this project aiming to consult with the member of the University, it seems not to be a serious problem to the student and staff in the University to download and install a small applet. This needs to be verified in the practical case studies.

## **5. Conclusions**

This study effectively implements virtual reality technology in visual representation of urban planning and design for the public participation, and systematically merges other relevant technologies, such as ASP, to enable the online survey associated with the interactive navigation of the virtual reality models. The specific functions are also provided in this system to facilitate people's participation activities. Both the advantages and disadvantages addressed though the discussions of this project are depicted. Some possible solutions to these, which are based on current technologies, are also suggested. Although this virtual reality participation system was not applied in the real participation practices due to various reasons, it was a great experiment and study for this research project. The experience addressed in this study can obviously support the development and implementation of virtual reality in web-based public participation in future. Today, with booming of using the broadband Internet connections and more powerful PCs, the planning and design representation based on virtual reality technology will be more and more practical to the web-based public participation. It is also believed that more desktop VR techniques will also be developed to be the solutions to the problems suffered in the current application of VR technology to represent large-scale urban environments.

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