Spreading of the cultural heritage by means of multi-configurable, low cost virtual reality techniques

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Abstract

In the last few years, computer graphics techniques have been applied to preserve and promote the cultural heritage. In this first steps the bottleneck of these applications developed was the price of the hardware that limited the use of these tools to museums or exhibition rooms. Nevertheless, the fast increase of graphic capacity of the computers allows the development of high-quality complex applications which can be visualized in personal computers. This is completed by multidisciplinary research groups that focus their efforts on the most relevant aspect of the learning and presence sense in virtual environments.

In this paper, an application of V.R. techniques to the promotion of heritage patrimony bases, in a PC platform, is presented. Focus has been put into high screen quality, multiple screen, multi-user, stereoscopic image, 3D sound and multisensorial environments as well as the high transportability, scalability and low price aiming at a quite widespread use of this hardware.

The virtual reality application developed shows the old part of Santiago de Compostela, European City of Culture for the year 2000. The model of the city is complex enough to prove that it is possible to use PC´s as visualization engine, over high quality and complex models.

1. Introduction

Santiago de Compostela lies at the end of the Pilgrim's Route to Santiago. This route was a melting pot of cultures, a disseminator of tendencies, a meeting place for peoples and their languages and consequently centre to common European awareness. Goethe said, "Europe was created on the Pilgrim's Route to Santiago·" The European Council and UNESCO have declared the Pilgrim's Route to Santiago and the city of Santiago de Compostela a European Heritage Site and a World Heritage Site, respectively.

The importance of preserving the cultural heritage of different peoples, city or region has increased considerably in the last few years. The preservation of this remains can be helped by the computer graphics in two different ways: on the one hand it helps or complements the archaeological techniques developed by experts. On the other hand spreading the knowledge of the cultural heritage to the general public by means of virtual exhibitions. Using 3D reconstructions the experts can simulate, discuss about and evaluate different solutions without modifying the original element. Virtual exhibit allows travelling to old civilizations or navigating historically valuable buildings by means of virtual reality techniques. In these cases, the users have to go to museums or virtual centers where, based upon graphic stations, virtual environments are shown[1].

Recently, the arousal of the new graphic accelerators for PC personal computers with workstations performance and the developments of new immersion devices for home use (as for example Sony Glasstron) make us think about a fast evolution and use of the virtual reality at a higher scale. This evolution is strongly supported by the video-game industry, where new graphic accelerators are developed every six months, performing twice as well as their predecessors. Nevertheless, only, a few V.R. applications using the PC as their hardware platform have been developed, mainly focused on single-person experiences[2].

2. Goals of the project.

The goals of the project could be divided into two clearly differentiated parts: cultural goals and technical goals.

The cultural goals could be summarised in developing a model of the most significant buildings of the city of Santiago de Compostela with the highest possible degree of quality leaving no chance for speculations as to its fidelity and also proposing ways of incorporating cultural information to the scene. The first aim can certainly be fulfilled by using such software as 3D-Studio, Photoshop and AutoCad. With this model we would develop a walkthrough application which we would later enrich with the cultural information.

From the technical point of view the main goal is to develop an application that allows the rendering of this model with a high presence sense and with a high and stable frame rate using Pc platforms. A second goal is to build several prototypes adapted to concrete application to explore the flexibility of the system architecture for presentation, form a single user to an audience.

3. Virtual Santiago.

Different kinds of sources have been used in order to develop the virtual environment. The model has been cast from blueprints to given by the Consorcio de la Ciudad de Santiago de Compostela, both from CAD as from original blueprints. High resolution digital cameras have been used to capture the textures of walls, columns, glass panels and in general any element being part of the scene. The model built has been placed on the TIN mesh of the city terrain.

A group of expert historians, designers and programmers have worked together to simplify the polygonal model obtained. They focused their efforts on mantaining a model as faithful as possible for rendering with a high and stable frame rate.

Different meetings where held between educators, historians and programmers to study the access to the cultural information from the model. Their conclusion was to opt, for a first stage consisting on incorporating sounds and informative videos and a second stage consisting on the development of virtual guides showing the environment.

4. Virtual Santiago Presentation

From the technical point of view the main problem is the development of an application that allows the rendering of the model with a high quality and multiple presentations.

A modular application with a network support was developed. In general, the application presents a server/client architecture. It can be executed in a single computer or renderised in a network for more complex presentations. The server is the system's manager and is in charge of the most of the tasks of a V.R. application except for the graphic rendering which will be done by the clients (graphic clients, figure 1). In the case of a presentation with a multi-screen display more than one graphic client may be used as render system. In case of just one computer, for example, one user at home, this would be the one in charge of performing all the tasks[3].

A first prototype has been developed for a presentation for multiple users with a multi-screen display as shown in figure one. In this case the system is formed by 4 computers. One of them is the system server and the other three the graphic clients.

The server receives the inputs of the user's interaction devices, calculates the user's position in the environment, the collisions with the objects and indicates to the graphic clients the positions of the user's point of view in the visualisation process. This system consists of a PC, in this case a Pentium II at 350 Mhz with a Ndivia TNT processor based graphic card, two sound cards (for sound effects generation), Soundblaster Live for 3D sounds and Soundblaster PCI-128 for 2D sounds, joystick, Analogical/Digital card (DAC DT-128 a from Datatranslation) and a tracker system Polhemus Insidetrack-II.

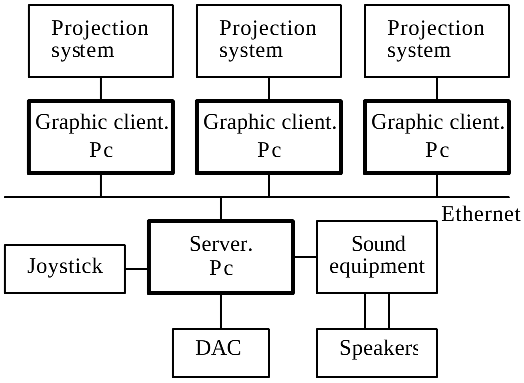

Figure 1: first prototipe.

The graphics clients are based on PC's, Pentium III at 500 Mhz with a Ndivia TNT2 processor based graphic card. This element visualises the scene or part of the scene corresponding to it according to the user's position, sent by the server. It is the one in charge of making all the necessary graphic tasks to keep a high and consistent frame rate. In the basic prototype three graphic clients have been used, each one of them visualising one part of the scene. The whole image is composed by the link of the three images generated by the clients and projected over a semi-hexagonal structure. The user or users stand on the centre of this structure so that the whole of his vision area is covered. With this architecture and at the working resolution 1024*768 per screen with a vision area of 3072*768 pixels, 32 color bits (real color) is achieved. In order to visualise this environment a VREX-2210 projector is used, allowing stereo vision with passive glasses (Figure 1,2).

The application of all the graphic clients is always the same, and it will be enough with specifying by configuration file the part of the scene that each graphic client must visualise. The scalability of the display system, the number of graphic, clients is, thus, variable. This application has been developed using OpenGL and multimedia SDK for Windows[4]. In order to optimise the render process we opted for the dynamic generation of render lists managed by an expert system. This list is formed by the objects close to the user and by what he could see next. When the user changes his position, the necessary objects are incorporated or eliminated from the render list. The fact of an object not being renderised doesn't necessarily imply that its geometry and material are not stored in the system's memory. Reading this (specially in the case of materials) from the disk would be too slow, so it takes part of a list that is not active at that moment but that is memory resident. Of course, many classical walkthrough techniques have been widely used to keep an adequate frame rate [5, 6, 7]. The minimum value of 17-20F/s is enough to keep the immersion sensation up.

Once the application's base had been developed (the user can walk through the city) and the rendering process was done in a stable way, the next step was enriching it all with elements that increase the user's sensation of presence (sound, atmospheric effects and environment elements) and incorporating cultural information provided by experts.

5. Sound

An important aspect of this system is the sound. The system can generate two kinds of sound, 3D and 2D. These tasks are done by two sound cards and two sets of speakers. The user/users, sit in a chair, are surrounded by 4 speakers that transmit the 3D sound. A set of bass shakers in the chair and the ground are in charge of transmitting vibrations, shocks and any special effect. The API used for sound management is DirectSound.

In the proposed application we can find three kinds of sounds, ambient sounds, Foley and informative sounds[8]. Ambient sounds imitate the ambience of the city; we have included here wind, water, the sound of fountains, rain, etc. These sounds are characteristic of each point of the city and guide the user when identifying places by hearing. Foley sounds are associated to the ambient but are listened in an unpredictable way (for example, the sound of the user's steps changes according to the kind of ground he or she is stepping over, in closed areas there are reverberation phenomena...). The informative sounds also indicate in which street, square or monument the user is when walking through the city.

6. Information

The application presents a set of informative elements. The information included is shown by means of videos (sound and images). These were elaborated in conjunction with educators and historians and try to point up the relevant aspects of the history of that place or element. The videos are played on moving screens inside the model, close to the elements they describe. While the video is not played, the screens show a 'I' letter as the international icon for Information.

7. Atmospheric phenomena.

The user can live different atmospheric phenomena as light rain and a storm at day or night. The rain has been generated by means of particle systems to which special effects such as thunders, lightning, real humidity and air fluxes have been added. These effects are achieved by a combination of fans, stroboscopic lights, sprayers, graphic and sound effects activated by the server and its I/O card.

8. Other Elements

There are a series of other elements of the environment which are difficult to classify and that improve the interface with the user such as: doors opening and closing, flux of water in the fountains, clock bells sounding every hour, flags waving at the wind, clouds moving, etc. These elements make navigation more natural and surprise the user, increasing his or her curiosity to know the environment.

9. Audience prototype

Different prototypes of this system have been developed where both the size and the number of the screens have been changed. Nevertheless, the three screen basic configuration is the base which has been shown all through the paper. The first prototype presents a structure composed by three screens of 2,40*1,80m. The audience sitting in two rows of seats can navigate in the model by means of a joystick with feedback, enormously increasing the immersion sensation, (figure 2).

Figure 2: *Big prototype*

In SIPAC'99 [9] a second prototype was presented, in this case the screens had a 1,14*0.98m size and the joystick with feedback was substituted by a steering wheel with feedback, as it was more intuitive. In this case we were looking for the experience of experts in cultural heritage about the realism of the model and the information it supplied. The result was very positive, and it was especially remarkable the new gate opened to cultural heritage diffusion by means of this tool. In this second case we were looking for a structure that could be easily transported to congresses or exhibitions. Figure 3.

Figure 3: *Portable prototype, laboratory picture.*

In the different configurations the application and therefore the visualization ouput is always the same, of which some images are shown in Fig. 4 a, b, c, d (screen shoots).

10. Single-User prototype

The application is clearly visible in a single PC. In our case a Pentium III at 500 Mhz with 512M of memory, a TNT2 graphic card and a Sound Blaster live sound card has been used. In this case the sound has had to be degraded because of the big amount of memory which has to be used and which would drift too far from the capabilities of a standard PC. Fig 5. This prototype uses an Head-Mounted Display (HMD) as visualization element.

Figure 5: *HMD version, laboratory picture.*

11. VRML-version

The main objective of this system is the development of an application which would allow the " visitors" to get to know the city of Santiago de Compostela by Internet and which would also serve as a meeting place and a forum for discussion. Knowledge of the city will be possible through the development of a VE which recreates the city. The creation of a forum for debate will be achieved by adding multi-user capacity to the VE developed. With the creation of a multi-user VE, the different users will be able to share the environment and exchange information with one another. Each user will be represented by an effigy known as an avatar. These avatars make it possible for the user to be represented in the environment and also to introduce him/herself to the other users of the system and to interact with them through gestures. For more detailed communication the users can send messages via a chat program (Fig 6).

The application is based on client-server architecture. The server stores the HTML pages (Hyper Terminal Mark-up Language), Web-pages, the VRML environments, and a database which contains traditional information (2D, text and photographs) which the clients can download. A server program written in Java language, is responsible for dealing with clients´ requests (requests for information, connection to, and disconnection from the virtual world, ...) and the updating of the local VE (once it has been downloaded) of each client. When the server receives a request for connection, it sets up a communication channel with the client and waits for his/her requests, in such a way that each request, produces results and sends them back to the user. Each client is controlled by an independent "program" (*thread*), which makes it easy to use: using many Java processes means that the program is able to maintain control of the clients connected. This mechanism was used to construct a network server which accepts several incoming requests from the clients. The database in the server is responsible for the storage of traditional information which amplifies the information contained in the VE.

Clients access the database from the multi-user environment, using ASP language (Active Server Pages) and they visualise the information obtained in a frame adjacent to the shared virtual world. It is important to underline the fact that the database is not directly related to the Java server program. It receives requests directly from the VE, through the VRML model which controls events in the VE. Therefore, it is completely independent of the server program: this information is not updated for all clients (as occurs with changes effected in the virtual world), but only for those who request it, so that each client can visualise different information on his/her screen, even though they are sharing the virtual world.

With regard to the clients, the interface of the application is formed by an HTML page. The VE is integrated in this page and forms the graphic heart of the application at client level. This environment and the representation of each user in this world (*avatar*) are developed in VRML.

One characteristic which differentiates multi-user environments from other technologies is the degree of participation between users and with the VE itself. The users are more immersed in these worlds than in worlds based on texts or 2D worlds with limited interaction. The participants tend to strike up conversations in which they introduce themselves, favoured by their "physical presence" in the environment, as happens in real life when two people meet in the street [10]. That is why it is essential for users of distributed virtual worlds to introduce themselves so that the impression of sharing the same environment is enhanced. This representation known as an avatar, is a modelled structure (body) and other attributes (behaviour), which substitute the user and his/her point of view in the virtual world. It is really the avatars which give the sensation of population and community to the VE [11].

The presence of avatars is fundamental to the application: it provides information about Compostela, but at the same time, it shows it in a welcoming hospitable light. That is why exchange of opinion, on the part of the users, is so important. It is preferable to the typical information a tourist can obtain. This exchange of opinions is much more feasible if they are expressed by physical entities within the system: a "written" conversation (chat) is enriching, but it is much more so, if a "face to face" meeting where physical gestures are possible, takes place.

The system has four different avatars available for users, which have all a series of useful features both for the clients they represent, and for the other users connected who are watching. The name of each visitor is placed above the avatar, visible from any position: this favours the identification of any other avatar in the VE by other users. This increases the user's feeling of individuality, quite diminished in virtual worlds by the uniformity of the avatars and limited communication. The avatars have a limited spectrum of gestures (smiles, winks), which add considerably to written communication via chat programs. The four avatars are easily distinguishable, because two different design philosophies were followed.

Three of them were modelled on the official mascot for the Año Santo 99 (Holy Year). One masculine, other feminine and the third avatar is the previous effigy on a bicycle.

The design of the latter is quite different from the others, which are completely fantastic generic figures. In this case, the user must identify with his/her virtual representation more strongly: through Java programs it is possible to impose the texture of the user's face (taken from a picture) on the avatar's face. This means that users are able to recognise themselves in the virtual world.

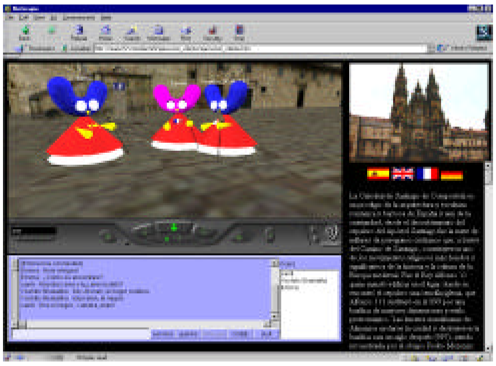

Figure 6: *Vrml.cliente screen-shoot*

12. Conclusions

The client-server architecture to support several applications based in virtual environments has been developed. Single spectator and ambience prototype has been built to explore the flexibility of the architecture and its adequacy to cultural heritage and tourist spreading. The system presents a high modularity, being trivial the increase of screens ranging from a single screen to n screens, being able to cover with no problem 360º of vision. The validity of PC platforms as visualization tool has been proved even when doing it over wide and complex areas.

The image quality obtained is enough to this kind of applications. The visualization system displays per screen 1024*768 pixels with 32 colors bits at 17 frames per second in stereovision.

In the architecture, the right use of algorithmic and artificial intelligence techniques increase the frame rate notably The 3D sound increases the immersion feeling, allowing the user to locate objects in the 3D space just by hearing. The use of joysticks and steering wheels with feed-back increases the interaction with the user and the sensation of presence.

The historical city of Santiago de Compostela has been recreate in a virtual environment enriched with sound, meteorological effects and cultural information.

The accessibility of information from the environment increases the learning aspects of the application.

The inclusion of dynamic elements in the model contributes to decrease the aseptic or void sensation produced by the absence of living beings.

The vrml-version has a number of clear advantages in comparison with traditional systems, because besides containing written and photographic information, it also introduces a new 3D perspective. The possibility of several users sharing information in real time guarantees that it will be updated, which is an enriching cultural experience. It is a novel way to show the cultural and monumental content of a city, in a friendly and attractive way.

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References

1. Erhard. Berndt and Jose Carlos Teixeira,"Cultural Heritage in the Mature Era of Computer Graphics", IEEE Computer graphics and appliaction, January/February 2000, **20**(1), pp. 36-38.

2. William Ribarsky, "The times they are a-changing: PC graphics moves in", IEEE Computer Graphics and Applications, May/June 1998, **18**(3), pp. 20-25.

3. Sandeep Singhal and Michael Zyda, "Networked virtual environment: Design and implementation", ACM Press Siggraph Series New York, July 1999, ISBN- 0-201-32557-8.

4. www.opengl.org, www.sgi.com

5. Matthew M. Rafferty, Daniel G. Aliaga and Anselmo A. Lastra,"3D Image Warping in Architectural Walkthroughs", Proceedings Virtual Reality´98 Conference VRAIS '98, March 14-18, pp 228-233, 1998.

6. Gernot Schaufler, "Exploiting Frame-to-Frame Coherence in a Virtual Reality System", VRAIS 96, Proceedings pp95-102 1996.

7. Stephen Chenney, Jeffrey Ichnowski and David Forsyth. "Dynamics modeling and culling", IEEE Computer Graphics and Applications", March/April 1999, **19**(2), , pp 79-87

8. Anderson, D. B. and Casey, M. A., "The sound dimension", IEEE Spectrum, March, 1997, pp. 46-50

9. Demo presented in SIPAC´99 International Symposium of Heritage and Culture. Santiago de Compostela, Spain, October 1999

10. R. Schroeder, Networked Worlds: Social Aspects of Multi-User Virtual Reality Technology, *Sociological Research Online*, **2**(4), 1997.

11. W. Broll, Extending VRML to Support Collaborative Virtual Environments, *Proc. CVE'96, Workshop on Collaborative Virtual Environments*, pp 47-54, 1996.

a) Obradoiro Square

b) Interior of the cathedral

c) Claustro of Fonseca

d) Plateria´s fountein, raining day

Figure 4, a, b, c, d: *Screen shoots of the visualisation systems*