

Certosa virtual museum: a dynamic multilevel desktop VR application

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Abstract

Starting from the exigencies of restoration, safeguard and promotion set by Bologna City Council for its Museum of the Certosa Cemetery, a multilevel application has been developed. Its main features are dynamic generation of models, interaction with objects, link to relational multimedia database, DTM and a friendly, computer games like interface. The outcome is a flexible product, both from a technological point of view – it can be experienced on low cost platforms as well as in HI End systems - and for the possible kind of fruition, that can involve several different groups of users.

Keywords:

Multiplatform application, Virtual Reality, Communication, 3d User Interfaces.

1 - Introduction

The performance of commodity graphics hardware has undergone a sustained increasing trend that does not seem to stop. This evolution, driven mainly by the huge game market, has shortened the performance gap between HI END VR installations (virtual theatres SGI based) and low end PC, not only on peak performance, highly optimized dedicated game engines, but even on general purpose portable (Open GL based) VR renderers. This has opened up the feasibility of portable applications where VR interaction has a pervasive role¹.

The Bologna City Council project for a Museum of Certosa-VR is an example of such new applications, where a key point is the application of the same VR interface (both modelling and code) to different usage contest. Different target users will use the same interface for different tasks and purposes^{2, 3}.

For the project of the Museum of Certosa in Bologna, numerous requirements have been set as prerequisite so that the application has been developed aiming to achieve an appealing product for cultural and didactical purposes, a tool for the ordinary management of the cemetery carried on by local administrators as well as an attractive way for communicating information to tourists and, last but not least, a scientific apparatus for academic research. The 3D virtual model become the pervasive interface for all interactions, leveraging on the perceptive capabilities of the users to simplify interaction with complex environments that can be navigated, modified and queried through the

link to more than one relational Data Base at a time (GIS, Multimedia data , etc.), becoming an interface for accessing different information^{4, 5}.

Following, in this paper, using the case study of the project of the Museum of Certosa in Bologna, we will describe in detail the components of the Certosa project: in the first section user requirements will be outlined, in the second section we will describe the architecture of the application, based on OpenGL Performer; in the third, some key features of application, adopted to accomplish a good trade off between speed and quality of the rendering; the fourth section describes the different levels and modelling scale of the artificial environment - from sky to underground; the last section describes the structure of the integrated databases, used both for querying and generating the dynamic models.

The driving constraints of the application derive from both the physical structure of the monument and from the administrative, social and educational goals settled by the City Council management.

2 - the Museum of Certosa: user requirements

The Certosa in Bologna is, for sure, one of the most important monuments in the city, both from an historical and artistic point of view. It is among the most ancient cemeteries in Europe and, in spite of its extraordinary importance, the site has lost relevance in the public awareness, maintaining it just in narrow communities of histori-

cal and artistic researchers. Until now it has received a limited attention also in the organization of touristic frameworks and we must not forget that death, as a theme of reflection, has undergone a sort of removal in our modern sensibility.

The general decrease in the quality level of cemeterial architecture highlights even more the uniqueness of the sculptural and architectural heritage of the Certosa that, for its extent and the related difficulties in keeping it, has suffered even stealings, vandalisms besides a growing need in upkeep.

Starting from these premises, Bologna City Council conceived an organic intervention with:

- a restoration plan;
- a database collecting every piece of information about the Certosa: the digital model, the land register about the tombs, their artistic cataloguing;
- a specific program for protecting the whole site against damages due to thieves or vandals;
- a unitary project involving the entire area around the monument with the realization of green areas, workshops for sculpture, artistic foundries and artcraft centres in order to awaken again the link between art and cemeteries;
- a serious communicative effort aiming to spread the knowledge of the Certosa among citizens, tourists, and students.

In order to reach these goals a specific application has been projected and provided with a high degree of visual impact and flexibility, capable of integrating different sources and to attain and satisfy exigencies of users with different backgrounds:

- for the tourist, who still has to visit the monumental site, the main requirement for the application falls on its lightness in order to enable the set up on various low end PC disseminated over key points of the city for delivering information about the city and its attractions. At the same time, it is necessary a good degree of technological flexibility for adapting the application to a SGI Irix platform for the immersive fruition in a space that the City Council is organizing in Sala Borsa, a central place where, in a relevant historical and archaeological context, the city library has been set up and meetings and cultural events open to everybody are held.
- for visitors and for young students going to the Certosa, the application should be appealing, provided with a simple interface for navigating and inquire it and capable, anyway, of supplying any detail that mere curiosity or real desire of knowledge could inspire. At present the application will run on totems but a study is undergoing for integrating it with mobile systems in order to increase the context awareness.

- at the same time, the application should be used by City Council employees who are in charge of the management of the cemetery and of the surrounding urban area, who must guard the site from stealings and damages and have to organize campaigns of restoration. From hence the importance of linking databases as the land register and place the model in its environment along with georeferentiated maps;
- for an academic audience the interest lies in the range of attainable information. Data are organized in different DB – about, for example, art history of statues, architectural aspects or historical information about people buried in Certosa – queriable at the same time through the same 3D interface, simplifying comparisons and research work.

3 – Performer libraries for multiplatform solutions

We decided to adopt OpenGL Performer graphic libraries, lately with a version for Windows, with the explicit aim of developing an application adaptable to low cost PC – the desktop systems in the visitors point at Certosa and in other places arranged for tourists - as well as to the HI End immersive graphics environment that the City Council is organizing.

It is undeniable that Virtual Reality applications are making available to users more and more realistic simulations and, especially when perceived in an immersive environment, they are increasingly useful not only for cultural and educational purposes, but also for decision-making.

A Virtual Theatre, as the one that will be open to the public in the Sala Borsa in Bologna, can show models in a 1:1 scale, fostering a direct and natural perception of space and proportions. The semicircular screen amplifies the sense of presence in the reconstructed environment that, of course, can be simulated even better if enjoyed stereoscopically. Moreover, it enables a collective view and, therefore, an immediate exchange of impressions among the public. Furthermore, politicians and local administrators, who should take decisions on public projects, or even citizens, asked to give an opinion, are able to take into consideration hypotheses that, otherwise, could speak only a technical language. Nevertheless, even if Virtual Theatres can be ideal environments for visualizing landscapes and urban areas along with 3D models, the huge cost of this kind of installation and the space that must be dedicated to them can suggest and favour desktop solutions, cheaper, easier to manage and, lately, with progressively higher quality levels.

That is why the use of flexible libraries, adaptable to HI End as well as to desktop systems, can be considered as the best solution. SGI OpenGL Performer graphic libraries are available for Microsoft Windows, Linux, SGI Irix. Furthermore, it has advanced features for rendering, uploads the most common 3D files (Openflight, 3D Studio Max, VRML, etc.) and, on the contrary of OpenGL, that bases

its rendering performance on graphic primitives, OpenGL Performer has a scene graph type of programming interface that simplifies the programming task without preventing a direct interchange to OpenGL when it is needed. Thanks to the nodes in the scene graph, there is the possibility of linking pickable objects to record of database, with text, images, audio, video.

4 – Light and realistic output: some tricks

First of all, models have been realized with Multigen Paradigm because this software enables to insert LOD, to use the scene graph and to optimise the budget of polygons. We applied to the models high quality detailed textures, obtained with a series of photographic campaigns held on site.

The navigation has been developed with the exploration of the world from a subjective point of view (FPS, with collision detection with the objects in the virtual world and perception of differences over the terrain). The point of view can be raised or lowered over the vertical of the terrain and there is also the possibility of a bird's eye perspective. We decided for a computer games like kind of navigation in order to attain the same familiarity of use with the artificial environments that now is so popular among teenagers and adults as well.

Moreover, peculiar technical solutions have been employed for increasing realism in real-time navigation as:

- LOD Levels Of Detail – with different levels of resolution of the objects visible in the virtual environment. This is performed in order not to slow down movements while showing particulars too far from the viewer or not in the line of view;
- IBR Image Based Render – this technique enables the use of a variable quantity of precomputed images in order to render complex shaped objects (like statues, trees, etc.); the displayed image is chosen according to the angle by which the viewer is looking at the object. In particular, we have applied this solution to the complex statue set in the underground section of the partisans' sacarium. The image has been formed with a set of twelve photos taken from different angles and offering the illusion of navigation around the statue;



fig. 1 - 2 Partisans' Sacarium. View of the statue from two different angles thanks to IBR

- Weather and environmental changes – the colour of the sky changes, simulating the passing of time and differences in climate, with fog, rain, etc. These events can be started automatically, depending on an “internal clock” that influences events according to an artificial timing, or by the user in real-time. In another option the sky has been set as a texture on the inside of an hemisphere set over the whole reconstruction;
- Audio – once in the artificial environment, users can hear natural sounds, as wind, cicadas, birds or other noises; the user has also the possibility of uploading his own files – more than one – and of linking them to events or objects or to use them as a background sound (for example, for the events, linking the walk to a different sound depending on the kind of surface that is being walked on; the objects can become source of the sound itself, for example a model of a radio can spread music). We chose the OpenAL library because it presents itself as the standard in multiplatform libraries for programming audio, also of a 3D positional kind. At present, OpenAL supports only wav files but they expect to develop the possibility of uploading other type of audio files in a short time.
- Automatic computing of shadows in the scene, depending on the setting of sources of light.
- Generation of polygonal writings with text coming from database. This aspect will be treated with more attention in the section five.

5 – From macro to micro level: the use of levels of detail

To enhance the user perception, especially for those target users like tourists or decision makers, there was the necessity to keep rendering quality and the rendering speed as much constant as possible during all the foreseen interaction. For these reason the technique of Level Of Detail has been used extensively.

During the modelling phase, three main environment have been modelled:

- the digital terrain model DTM (scale of kilometres);
- the monumental cemetery (exteriors, scale of hundreds of meters);

- the interiors (tombs, scale of meters) with single tombs with individual inscription (centimetres).

All this information has to be switchable maintaining as much as possible rendering coherence in term of detail (avoiding as much as possible popping effect) as well as temporal (keeping frame rate as constant as possible).

This goal has been a challenge, especially on desktop platform: the four scales has been modelled separately, implementing the switching inside the application and modelling a rough version to be used for higher level of detail model within the lower level contest .

Great care has been taken in the modelling phase to keep resource consumption within the available budget of desktop machines, for both polygon and texture. (64-128 Mbyte texture, 10.000-30.000 polygons). For the terrain part, a specialized modelling software has been used, (Teravista from Terrex) capable of managing GIS data in form of vector layers and aerial images, and automatically producing a LOD-enabled patched data structure (hierarchy of Open Flight files), while bringing colture data and vector features (trees, roads and rivers) in a consistent manner. The ability to automatically generating 3D models from GIS data have been essential in the urban planning usage of the application, due to the changing nature of original GIS data that reflect real changes in the territory. For Certosa exteriors, as before said, the modelling has been carried out using Multigen (Paradigm tech...), care has been taken to build perceptually rich models while maintaining within hw resource budget: IBR and billboarding technique has been used for trees, photographs for monumental tombs and texture material, much lighter, for everything else.



fig. 3 A panoramic view of the reconstruction over the area with the Partisans' Sacarium (wireframe)



fig. 4 A panoramic view of the reconstruction over the area with the Partisans' Sacarium

6 – Dynamic models and links to Data Base

The link to DataBase has been exploited in order to get a wide range of goals and satisfy the manifold requirements set by possible users^{6, 7}.

For lightening the model, polygonal writings are created with text coming from a database. The underground part of the Sacarium gathers the tombs of partisans arranged as superimposed boxes all over the walls. Using LOD it would have been necessary to realize resolute textures for each tomb in order to make visible the name of every partisan when sufficiently near to the wall. This technique would have made the whole work more complex. The solution was found in the realization of these polygonal writings over each tomb taking data from a database and making them visible in an automatic way when the viewer reaches a certain distance from the walls.



fig. 5 The Partisans' Sacarium, underground tombs. When the viewer reaches a short distance from the walls, over the tombs appear the names of the partisans buried there. The names are realized with polygonal writings generated with text derived from a database

As regards other information, there are several collections ordered in databases. To the partisans' tombs there is also the link to a relational multimedia database that can be queried selecting the tombs. For each partisan appears a dialog box showing the battle name, a short biography and, when available, images, pieces of movies and of documen-

taries, interviews in audio format, and so on. It is also possible to query the Sacrarium considered as an architectural piece of work. Selecting the structure, a link to HTML pages with technical drawings is activated. For near future is expected the realization of databases with information about the other graves: one about historical aspects, with data about common or famous citizens buried in Certosa; and another one about artistic aspects, with information about the pieces of arts adorning the tombs. The user, selecting the object he is interested in, can access both databases making his choice through a dialog box. This box will be used also for selecting the access to data coming from the land registry and useful for the City Council employee. In the same way as with the buildings in a city, cemeteries and their graves are catalogued and archived in a land register.

Last but not least, to the DTM has been linked a GIS with archaeological layers, since the area was an Etruscan necropolis.

7 - Conclusions

The application can be considered as a real tool of augmented knowledge. It can be installed on different platforms and can be used by a wide variety of users: for researchers, interested in studying data of various nature related to this monument; for public administrators, interested in managing it and its surroundings; for tourists, who have to be attracted to the site, as well as for young generations, that have to be involved in the understanding of their cultural and artistic roots. For everyone the communication of this huge collection of data passes through a sort of game metaphor used for valorising, diffusing and facilitate the relation with Cultural Heritage.

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