Databases and Virtual Environments: a Good Match for Communicating Complex Cultural Sites

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1 Introduction

Virtual Reality, as an educational tool, is evolving through the prototyping stage, aspiring to become an everyday instrument. However, experimentation is not a concluded process and it is particularly important to develop meaningful applications, capable of satisfying the requirements from an extended range of users. Such applications should offer not only flexibility from the usability point of view, but also portability, hence enabling the application to run on many different visualization platforms available today.

The project New Institutions for Communicating the City, of Bologna City Council, CINECA and VISMAN project conceived and are currently developing a complex VR application regarding several cultural sites of the city that will constitute the basis of a Museum for Accessing the City of Bologna. The fundamental idea of this case study is visual mediation. Thus an interactive visual portal has been conceived to allow easy access to historical and cultural contents. Choices are guided by vision and the virtual environment presents information in a user friendly manner. The actual territory that the application can visualize is the second most important concept around which the application revolves. This aspect enables a user to put into relation different historical events and topics, gathered under the same contextual "roof" that unifies even apparently disjointed cultural resources. The interaction with the virtual environment allows users to be immersed in a sort of *hic et nunc* but, at the same time, it permits them to retrace and understand historical events which occurred in the same area at different periods.

The framework presented here has been designed in order to eventually provide a complete and contextual access to already existing local digital products related to the same geographical area (mostly Virtual Reality applications developed at the Bologna University and databases produced by museums, archives and private research centers but without any preclusion to other future realizations). Combining these resources in a visual geographical portal not only unifies a set of applications, but also constitutes a more complex conceptual access, creating a new way to manage and use Virtual Cultural Heritage. A visual and geographical access enables organization and communication of huge quantities of data related to the sites of interest. The aim of the project is to democratize the information even further, taking it outside the narrow space of the archives or of the specialized libraries and so delivering it to a wider and differentiated audience.

2 Exposition

For the development of this complex VR application three different sites (two in Bologna and one in its surroundings) have been selected as a starting point for the process of valorization:

- the Certosa cemetery, that gathers several significant monuments, such as the Partisans' Sacrarium, the Great War Memorial, the Cloister III of the XIX century, with a great number of artistic graves, the medieval S. Girolamo's church and the Etruscan necropolis;
- the Memorial Wall, a monument raised in the central Nettuno Square, in remembrance of the Bolognese people killed in the fight for liberation during the Second World War;
- the area of Monte Sole, sadly known for the mass executions of civilians carried out during the Second World War. This event is known as the slaughter of Marzabotto, which comes from the name of one of the villages in this area.

The procedures and techniques used for visualizing and interacting with the site of Certosa can be considered as, more or less, the standard template for the development of other sections in this complex project.

The geographical interface is the starting point for accessing all the different 3D reconstructions and data. Over the DTM (Digital Terrain Model) of the area a simplified model of the entire complex of the Certosa has been set for a birds eye view. The blue-prints of the buildings, delivered by the Territorial Information Service of Bologna City Council, have been used for the realization of the DTM. Volumes of buildings were extruded from the polygons in the shape files by reading the information specifying their heights directly from the database in the shape file. The obtained geometries were gathered inside a scene graph. From the resulting objects, two kinds of visualizations were implemented: one realistic and one didactical. The first visualization depicts a fully textured scene, the second one is divided into periods with buildings of different colours identifying the time of construction.
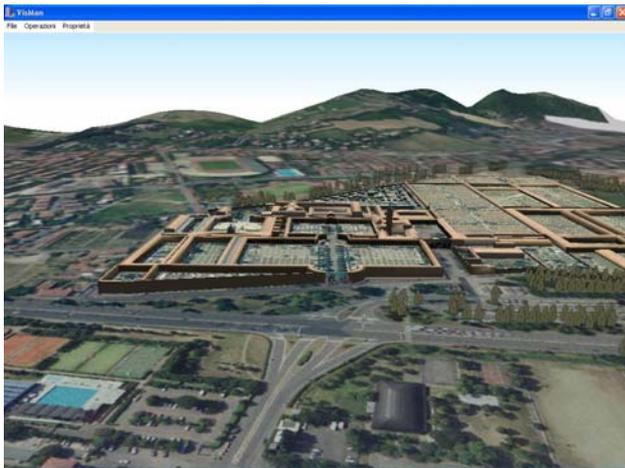
Figure 1: Navigation inside the landscape over the Certosa area textured in a realistic way.

2.1 Visman

The scene graph is designed to fit the VISMAN framework, the visualization software developed for interacting in various ways with the scene. Polygons are grouped inside nodes of a specific type ("group" type) with identification tags that enable the software to:

1) switch between models with different level of detail or pertaining to different historical periods but insisting over the same area. For example, from the general model of the whole Certosa it is possible to access detailed models about the most interesting areas;
2) insert IBR (Image Based Rendering) geometries;
3) add parts to the model (i.e. addition of sections built through the centuries);
4) connect to a relational multimedia database.

The main feature of the Visman software is the possibility to connect data from a database to a 3D scene graph. This feature can be used to display dynamic content such as brief messages describing objects behind the cursor and mostly for pop-up windows containing detailed data connected to a specific object in the scene.
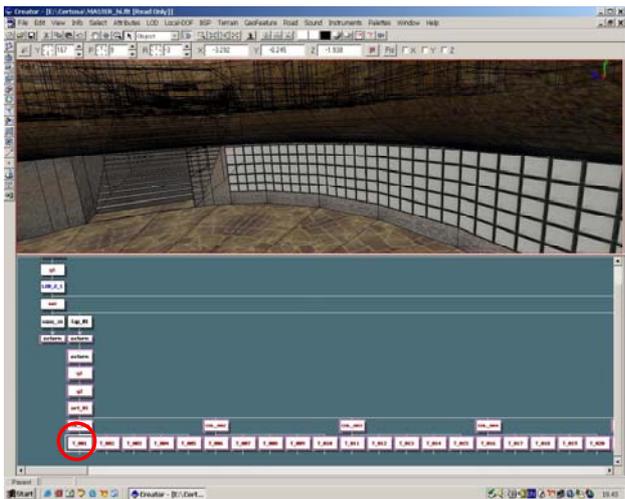

Figure 2: example of scene graph

2.2 Connectivity

The connection between an object in the visualization and a database is made using a naming convention. Objects inside the nodes of the scene graph are given a specific prefix; the rest of the name is a number which identifies the object in a univocal way. For example, in figure 2 we see the scene graph of the model, with highlighted nodes that will link to the database within the application.

An example is "T_0001", in which "T_" is the prefix that identifies this node as a special node which is bound to a database record, and "0001" is the key which is used to actually link the object to a record in the database. In figure 3 we can see the database table which is used to store the data; in particular we can see the column that contains the keys which correspond to the numbers included in the names of objects inside a node in the scene graph.
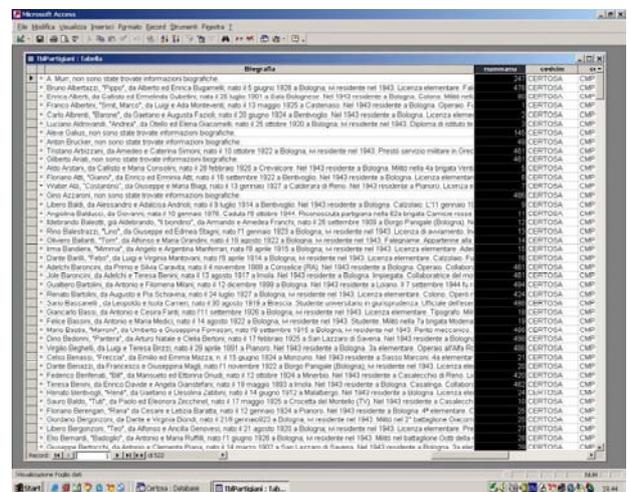

Figure 3: Column showing the unique keys identifying a record containing information

When the user interacts by clicking or passing the cursor over an object an SQL query is performed. If a record is found, a pop-up window appears which shows the data of the record, and the 3D object is highlighted.

3D models are created using Multigen Creator (a 3D modelling software developed by Paradigm which is optimised for the creation of real time graphics), thus models are automatically organised into scene graphs. Furthermore, models can be easily connected to each other by using scene graphs. Models organized into scene graphs have the sort of flexibility useful for multiplatform purposes and, in addition, these models can be used inside a Virtual Set. Created geometry which is to be bound to a database record is either inserted as a new node or inserted under an already existing group node which will be renamed using the naming convention described above.

The scanning of the scene graph at run-time is done using OpenGL Performer's routines of scene picking. Starting from the position of the mouse pointer, a virtual segment is cast into the scene, and collisions are detected. The collisions identify the scene graph nodes containing the geometries currently under the mouse pointer. Starting from a node, the scene graph is scanned in a bottom-up manner, starting from the leave nodes traversing the scene graph towards the root. If a node with a special prefix is

encountered, then the search of the corresponding record is started; if the record is found, a pop-up window which shows the corresponding data is opened. The final result of this interaction can be seen in figure 4, which depicts a highlighted tombstone and a pop-up window presenting the biography of the partisan buried there.
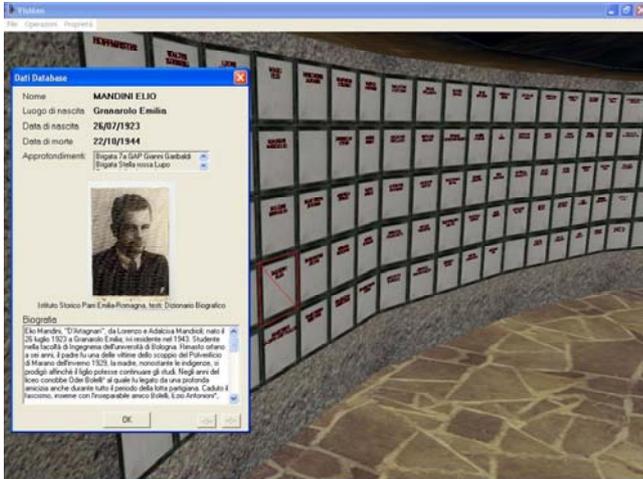

Figure 4: The result of a mouse click on a tomb: a pop-up window showing the data linked to the 3D object

2.3 Technology

This application uses Microsoft Access database and the connection is performed using ADO (Microsoft) libraries, but it is possible to adapt the application to deal with other types of databases and servers such as Oracle, MySQL, SQL Server etc.

The application was built using Borland C++ Builder 6. The forms shown in the pop-up window were also designed using this development environment. The forms were integrated into the application and personalized depending on the data to be shown inside the database.

A feature derived from this structure is the possibility to search for 3D objects starting from a database record. This is achieved by first retrieving the key field of a database table then creating a name with the database prefix "T_" as in our previous example, and the number identifying the database record. Finally, by using OpenGL Performer's routines, the scene graph is scanned, searching for a matching node. If a matching node is found, the point of view of the camera will change to point in the direction of that object, then travel to the position of the object, highlight it and display the information in the corresponding database record. This feature is very useful since a multitude of queries can be made to the database. Queries can contain either nicknames, years, etc. and the result of this query can be shown in 3D.

2.4 Features

The Certosa cemetery gathers several significant monuments, such as the Partisans' Sacrarium, the Great War Memorial, the Cloister III, S. Girolamo's church and the Etruscan necropolis. By referring to some of these sites, we are going to explain other features of our application.

- **Partisans' Sacrarium**: the original blue-prints of the architect Piero Bottoni were the base for the modelling process. The

peculiar structure of the monument, with a vertical development and an underground section, has led to the separation of the scene into two separate models, one for the outside, including the surrounding area and a link to information organized in a database by Bottoni's Archive, and the other for the inside section.
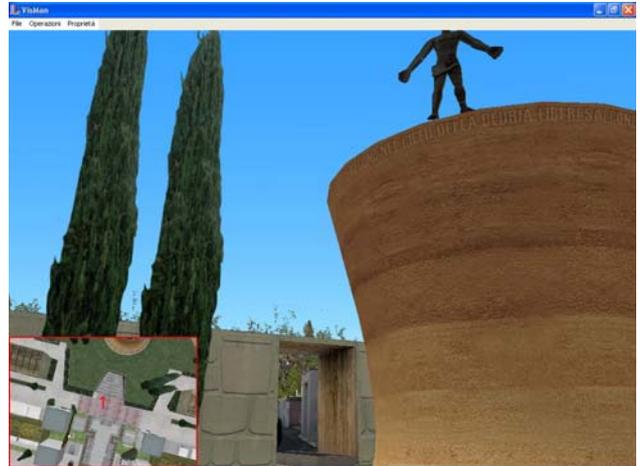

Figure 5: The Partisans' Sacrarium, outside view; a small map in a corner of the scene helps with orientation.

The underground section contains nearly 580 partisans' graves, each one linked to its related biography. Through the pop-up window containing the biographies it is possible to access other historical multimedia sources, such as videoclips, images and textual information about the partisans' brigades, significant historical events of the liberation war.

Figure 6: An historical video clip is shown inside the 3D virtual scene: a new medium contains an old one**.**

The descriptive text in the pop-up window forms is connected to a "text to speech" system. In order to reduce complexity of the overall model, the statue set in the middle of the Sacrarium is constructed using an IBR consisting of 12 photos. In order to optimize the texture memory storage, the names appearing on the tombs are polygonal. The geometry is generated procedurally by accessing the first two columns of the database of the partisans which contains name and surname.

Furthermore, it is also possible to invoke a map showing the cameras current position. This is a utility for easy orientation inside the virtual environment and it is shown in figure 5.

In order to easily adapt the application to different set-ups the software offers the option of introducing different environmental effects such as fog, changes in the colour of the sky, etc., but also sounds and noises may be introduced to further enhance the atmosphere.
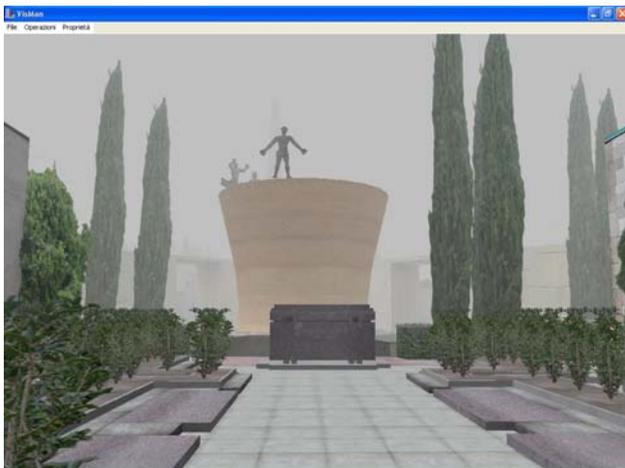

Figure 7: the outside area of the Sacrarium shown with fog**.**

- **Third Cloister**: a feature of the real structure lies in the porticos. The model was create by modelling a template portico and then instantiated this portico where needed. The model was textured by using the "render-to-texture" technique which allows to show complex shadows and realistic lighting in real time application.
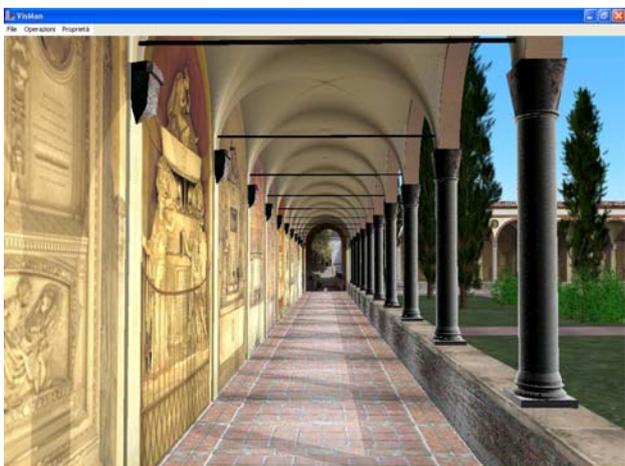

Figure 8: Reconstruction of the Third Cloister as it would have appeared around 1870**.**

The process of deterioration of the frescos and the statues has been simulated on individual polygons for each tomb, using a bump mapping effect. Due to the complexity of the model, two levels of detail have been modeled in order to maintain the fluidity of navigation. Vegetation has been created by using an historical map with botanical information.

As for the other sites, also the Third Cloister is connected to a database, related in this case to artistic information about the graves.

Techniques and solutions developed for these two sections have been applied to the others as well. For the creation of the virtual monument dedicated to the First World War, IBR and render to texture techniques were chosen to better represent the texture of the marble in the structure.

3 Results

This framework can be considered a new approach to Virtual Cultural Heritage. Due to its modular nature it can easily be extended to additional models and databases, creating new cultural and media connections.

Acknowledgments

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