Virtual Reality and Cultural Heritage examples:

The Mysterious City Fresco

The Domus Aurea

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Abstract

Cultural heritage can benefit greatly from the use of virtual reality. Among the demands of cultural heritage that this technology can help to satisfy are the following:

- *Giving laymen the opportunity to appreciate works from the past of which only fragments remain, or which contain cultural references that have been lost over time.*
- *Providing researchers with powerful tools.*
- *Ensuring the preservation of cultural heritage over risky restoring and degradation due to excessive number of visitor.*
- *Making virtual replicas that can be transported without risk to the original, increasing enormously the number of potential visitors.*

Two examples are presented: The Mysterious City Fresco and The Domus Aurea.

Keywords: Virtual Reality, Cultural Heritage

1. Introduction

Cultural heritage can benefit greatly from the use of virtual reality. Certain problems can be solved effectively by using real time computer graphics technology. Among the demands of cultural heritage that this technology can help to satisfy are the following:

- Giving laymen the opportunity to appreciate works from the past of which only fragments remain, or which contain cultural references that have been lost over time. The mental reconstruction of which only a few experts are capable is thus made available to the ever growing number of visitors to works of art and archaeological sites -- visitors who lack the necessary background to interpret the works on their own, either for lack of education, or because they belong to different cultures.

- Providing researchers with tools to compare hypothetical reconstructions, and which take into account elements from textual descriptions or two dimensional drawings that are not always easily perceptible at the same time.

- Ensuring the preservation of cultural heritage, whether it be from risky restoration works, or from degradation due to an excessive number of visitors.

Finally, the obvious consequence of making virtual replicas is that these replicas can be transported without risk to the original, increasing enormously the number of potential visitors.

2. Production of a virtual reality application

A virtual reality application is a communication tool, and should therefore follow the same guidelines. But because up until now the potential of computers to do computer graphics in real time has been very limited, a great deal of emphasis is still placed on the technology. It should be said that, because the techniques used are not yet commonplace, there is often a great deal of curiosity, especially among laymen, as to how the

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works are digitized. The question put more or less explicitly is:

"But how do you get everything into the computer?"

This paper presents one answer to that question.

A reconstruction in virtual reality consists of four fundamental components:

1) Construction of the model.
2) Creation of the textures.
3) Implementation of the viewing program.
4) Refinements.

It may also be necessary to take into account the creation of multimedia segments, just as in the case of a CD-ROM.

2.1 Construction of the model

The construction of the three dimensional model is generally done from maps and drawings of existing structures, or from reconstructions of elements which have been lost. The choice of the CAD program used to digitize the model is critical in terms of the options the program provides for real time rendering. In this sense the choice of programs is currently fairly limited, but the number is growing, and what is more, many elements can be produced using different tools and assembled later.

2.2 Creation of the textures

The textures, or rather the designs that cover parts of the model which would otherwise be of a single color, can be divided into two fundamental categories:

- materials
- images

As far as materials such as marble, wood and bricks are concerned, patterns are created from photographs of existing elements, which are then repeated indefinitely over the surfaces of objects believed to be made of that material. If no appropriate examples of that material remain intact, archaeological research can point to other places where one might find similar materials.

As for images, if they are at least partially intact, pieces of elements such as frescoes and decorations can be photographed and used as is. If not, one must search history books for descriptions of what was there, or if for example frescoes were moved over time and may now be found elsewhere, or else one may proceed by analogy and try to use elements which actually exist somewhere else or which have been reconstructed based on descriptions. The great advantage of digital technology is that all kinds of restoration are possible -- one can even try several restoration techniques at once -- in a way which is totally non-destructive and completely reversible.

Up to this point, the techniques used are apparently the same whether one wishes to produce a simple, uninteractive film, or else to obtain a model which can be manipulated in real time in virtual reality. In the latter case, however, particular attention must be paid both to the number of polygons in the model and to the number and resolution of the textures. Clearly the greater the number of polygons and the resolution of the textures used, the higher the quality of the image in virtual reality -- but the slower the application will run, in images per second, until it eventually reaches a point where the sense of movement and of "presence" typical of virtual reality applications is lost completely.

2.3 Implementation of the viewing program

Once the model has been created, the viewer, or browser, comes into play. The visualization of the model is made possible by a program which reads the model and texture files, and makes them visible to the user by means of various input and output devices. A great variety of devices is available. For input they range from the simple combination of mouse and keyboard, to a more or less sophisticated joystick, to mechanical or magnetic sensors with many degrees of freedom. As for output, they can go from a simple monitor, big or small, to multiprojector systems for big screens, flat or curved, helmets of varying sophistication, and stereoscopic visors. The viewing program also performs a series of optimizations which may or may not depend on the data, which vary from application to application. Finally, the viewer performs various animation effects to complete the virtual reality application.

2.4 Refinements

By refinements, in the case of virtual reality applications applied to cultural heritage, we mean a series of functions which are secondary but still important. Though it is not necessary to reach the amount of information contained in a typical multimedia CD-ROM, the application should contain an introduction to the subject matter in the form of audio or video, a guided tour which illustrates the salient points of the reconstruction and explains the most important details, and the option to jump quickly from one place (or "universe") to another. This makes it easier for someone who wishes to present the application to an audience, either automatically or with a guide who might speak of various aspects of the reconstruction in a non-sequential manner.

3. Communication

Going back to what we said earlier, a virtual reality application should follow the same rules as any other communication product. Telling a story, in a general sense, is fundamental. Putting the reconstruction into context with descriptions in the form of audio, video or animation, doing things which are impossible in reality like "entering" paintings or simply "flying" to view the model from unusual or inaccessible viewpoints, entering inaccessible places or traveling in time, are some of the things worth attempting in order to reach a non-expert audience. And the beauty of the technology is that all this can be done without sacrificing scientific rigor, but rather providing a scientific tool to researchers, making it possible to verify different hypotheses, comparing one to another without endangering the works of art.

4. Examples: The Mysterious City Fresco and The Domus Aurea

As examples of virtual reality works in an archaeological context, we present two of our productions:

1) The Mysterious City Fresco
2) The Domus Aurea

The mysterious city fresco was shown for the first time, in a greatly simplified version, on the occasion of the anniversary of the founding of Rome (April 21) in 1998. Just two months beforehand, in a tunnel beneath a hill in Rome called Colle Oppio, just a few steps from the Colosseum, behind a wall dated to the 1st century A.D., archaeologists had unearthed a fresco depicting a mysterious city, in a style which was absolutely extraordinary for the time: the fresco was painted from a bird's eye perspective, and incorporated shadows and reflections in the water.

Today, even as we write, the excavation continues, and more is about to be brought to light, but the city has not yet been identified, and experts have yet to decide whether the city is real or imaginary.

The virtual reality application was conceived for machines with a very high level of graphics performance, to be used in public by exhibitions and museums. The "story" told by the application is that of the discovery in the tunnel, in which the fresco is reproduced in extremely high detail, making it possible to "see" it from as close as a few centimeters (which in reality is not generally possible).

After observing the surprising detail of the fresco, the city takes form, materializing like a miniature model which the visitor can turn as he wishes to compare details with the image, which remains in the background. Next the observer "shrinks" down until he is small enough to walk through the city, and see it from the point of view of those who lived there.

In the future, yet another step will be taken, and the voyage back in time will be complete, when the city will be populated by virtual inhabitants going through their daily routines.

The reconstruction of the Domus Aurea (Nero's palace) was conceived for PC machines, albeit PCs with high performance graphics. The first version was demonstrated on the occasion of the launch of SGI's first graphics PC, the Visual Workstation, on January 11, 1999, in Mountain View, California.

The Domus Aurea, which is also buried beneath Colle Oppio, has been closed to the public for the past 20 years, due to the precarious state of the buildings, but last year the restoration work was accelerated, the objective being to reopen it to the public by this year.

Among the rooms and the frescoes of the Domus, the most famous is the hall in which it seems the emperor received his guests: a ray of sunlight, shining through a hole in the cupola-shaped ceiling, illuminated a throne placed in the center of a rotating stage, which was powered by hydraulics. Around this throne, guests reclined on triclinia and, thanks to the rotation of this stage, could admire the emperor as he came to face them.

As we write, the application consists of a visit to the Domus as it is today, followed by a reconstruction of how it was in the splendor of Nero's time. To increase the visual impact, the technique of radiosity was used to generate very realistic lighting, in spite of the limited graphics performance of the target hardware.

In its final version, the application will tell the story of the Domus by showing how it was used, featuring echoes of the voices of its inhabitants.

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