Virtual Museums and Virtual Realities

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Abstract

The notion of *virtual museum* is discussed and related to various developments in user-interface, software, and communications technology. A prototype implementation, intended to explore the integration of interactive 3d graphics with video imagery is described.

1. Introduction

The traditional museum is a setting which allows people to visit and admire artifacts in pleasant surroundings. However there are many characteristics of this view which constrain the operation of museums. We will examine some of these characteristics and discuss their resulting disadvantages.

First, the artifacts on display are supposed to be *real*. For example, a real amphora is displayed and not its photograph or some other facsimile. There are many disadvantages to this practice: Some artifacts are too large, or may be incomplete, making their display difficult; expensive measures have to be taken to assure security for the artifacts; and the displays need environmental conditions which preserve the artifacts and make it comfortable for people to view them.

Second, the setting for displaying the artifacts is *real*. That is, a building is specifically used for their display. Such a setting is very expensive both in its construction and its operation. As the number of artifacts increase, both new and old, museums have difficulty providing their archival and storage, let alone their display. As a result, a great number of artifacts have little possibility of ever being displayed.

Third, people have to come within direct *proximity* of the artifacts. This implies that people have to travel to reach the museum and then circulate inside to see the artifacts. While this encourages tourism, in general it is debatable whether it is the best approach. The people rarely see the artifacts where they were found, but instead where they can be concentrated for historical or financial reasons: artifacts end up being displayed where people are rather than in their natural environment. In addition, moving artifacts is dangerous and expensive.

Fourth, artifacts are usually *passive*. People can see them but they can not "play" with them. For older generations this is fine since they have been accustomed to see but not touch. For younger generations it is not sufficiently exciting. They want to directly explore different possibilities and see the results, but we cannot, of course, let children play with real amphoras, break them, and reconstitute them.

1. A version of this paper will appear in *Proc. of the Intl. Conf. on Hypermedia and Interactivity in Museums*, Pittsburgh, 1991.

In the end one wonders what is the actual purpose of the museum. It is not simply to display. Instead the goal is to create an *impression* on people and to make them *imagine*. The question remains whether displaying real artifacts in real settings for people to pass by and passively look at is the only or the best way to achieve such goal. Many changes already present in museums point to the contrary.

2. Easing the Constraints

The first constraint of *real artifacts* is not strictly adhered to. Photographs, slides and books have been used for sometime to create the impressions usually reserved for museum trips. More recently a similar role is being played by film documentaries and videos. Extrapolating this trend leads to multimedia representations of artifacts stored in a database accessible through computer programs. Museums have therefore to deal not only with their artifacts but with all the multimedia representations of artifacts (whether theirs or others) which are relevant to their theme.

It is becoming possible to also relax the second constraint, that of a *real setting*. We can show multimedia representations of artifacts (let's call them virtual, as opposed to real, artifacts) in real settings *or* virtual settings. A virtual setting is a computer model of a setting. The model may be based on a real setting or it may be completely imaginary.

The third constraint of people's *proximity* to the artifacts can also be relaxed. Documentaries have accustomed people to taking tours in museums without going there. Simulated tours are even better. They give the impression of actively participating in the tour rather than seeing a canned presentation. Live video and the possibility of diffusing through high bandwidth networks can make such tours even more exciting since it can enhance this sense of participation.

Finally, science museums have for some time accepted the idea of *active* as opposed to *passive* displays. Designing active displays is often expensive and time consuming when we deal with real artifacts. With virtual artifacts in virtual settings the possibilities are enormous. Each artifact can be represented by a software construct which can be manipulated in many ways.

What we propose is to ease all the constraints at once. In this way, a museum will deal with virtual artifacts, in a virtual setting accessible from a telecommunication network in a participatory manner. Such a museum is a service not a location. It may not exist at all, other than as bits of data. That's why we call it a *virtual museum*. In the next sections we will discuss the available technologies which can make such virtual museums realistic (sic!)

3. Technologies

Recent technological developments, and the maturation of earlier technologies, is furnishing the needed context to construct virtual museums. These technologies (see [9] for a highly readable description of many of the following) include:

1. high-bandwidth networks
   Current commercially available local area networks typically have a bandwidth between 1 and 10 M bits/second. Research prototypes have achieved considerably higher data

rates, and networks in the gigabit range may soon be widely accessible [7]. Combined with new data compression techniques, such networks will support a large number of digital video and high-quality digital audio channels. This allows one to construct, for example, video servers, i.e., video repositories that can be reached by network connection and that can send video information over the network in real-time.

2. multimedia workstations
The continuing progress in HDTV (high definition television), CD-I (Compact Disk - Interactive) and DVI (Digital Video Interactive) is spurring the development of multimedia workstations [8]. These machines allow applications to manipulate and present multimedia information (including audio, video, graphics, high-resolution images, and text).

3. hypertext / hypermedia
The extension of hypertext techniques (the linking together and cross-referencing of text segments) to multimedia information has led to hypermedia. If multimedia information is stored in a hypermedia web one can, for example, navigate from a video about a particular topic, to a textual description of the topic, to an audio recording etc.

4. interactive 3d graphics
High-end graphics workstations have now reached the point where it is possible to generate complex scenes at rates suitable for real-time interaction. For example, one manufacturer quotes 100,000 shaded polygons per second [1]. At 10 frames per second (about the minimum needed for real-time interaction) this allows scenes of about 10,000 polygons.

   When the display from such workstations is connected to an EyePhone[1] (a head-mounted display device which also provides the computer with head position and orientation data) one can surround the user with *virtual reality*[10]; i.e., synthesized 3d imagery which changes in response to changes in the user's orientation (and position). Finally, an input device called the DataGlove, allows the user to reach about and interact with objects located within this synthesized world [2].

5. groupware
Groupware refers to systems which support multiple users engaged in a common task within a shared environment [4]. *Desktop conferencing* is one example of groupware, it allows users to establish audio and perhaps video connections from their workstations and jointly operate a computer application such as a document editor [6]. Another example is the multi-user virtual reality system RB2 (Reality Built for Two) [2]. The definitive characteristic of groupware is that it provides each user with notification, or feedback, of what the other users are doing. In a sense groupware acts as a medium for group interaction.

6. active objects
Active objects [3] are programming constructs that possess a high degree of autonomy and local control. They are well suited for complex simulations involving many parallel

1. EyePhone, DataGlove and RB2 are trademarks of VPL Research Inc.

activities. In particular, active objects can be used to model *reactive* environments; environments which respond to the presence of one or more users.

4. Realizing The Virtual Museum

Given the above list of available technologies, the following scenario suggests itself:

- A 3-dimensional model of a (real or imaginary) museum setting would be produced using various modelling tools such as CAD packages. This model would contain layout (i.e., floorplan) information, visualization information (the color of the walls etc.), and an indication of the position of artifacts.
- With current technology, most artifacts would be too complex to handle as 3d objects (plus such data would be very time consuming to acquire), instead artifacts would be represented by high resolution images and video clips.
- Descriptions of artifacts, whether textual, graphic or audio, would be linked to the artifacts themselves as part of a hypermedia web.
- All the above data (museum model, artifacts, descriptions) would be available via network connection from a "museum server."
- Clients of the server run a virtual reality user-interface. When the client first connects to the server, the museum model is downloaded. As the user moves through the museum the server is kept informed of the location of the user.
- A museum server may allow multiple clients, i.e., groups may enter the museum. In this case the server coordinates and broadcasts group state information (such as the locations of all members of the group).
- Users may "activate" artifacts (for example, by pointing at them). This would result in a window appearing in their virtual world. Within the window the artifact's video or image data would be displayed. The user could interact with the window and activate any of the descriptive information associated with the artifact.
- Active objects would be used by the server to handle interactions such as the above. For example, if an artifact is activated by a client then its corresponding active object starts sending artifact information to the client (or clients).
- Active objects would also be used to handle more complex processes within the museum. For example the museum could respond to large groups by growing its rooms (i.e., increasing their size). This would require an active room object which monitors its number of inhabitants. Another example is a museum guide, an active object which follows a particular path through the museum and the hypermedia web (and "drags" along a group of users).

A system as described above could be built using current technology. Steps along these lines have already been taken. There are a number of virtual reality prototypes and products; also some museums have started to make the artifacts available in digital form. (For instance, the Smithsonian has produced a CD-I application [8] and the Gifu Art Museum in Japan has an

HDTV system for viewing its collection [5].) What is perhaps unique about the above proposal is that it integrates a number of technologies which have yet to be found together in a single application.

5. A Prototype Virtual Museum

One aspect of the previous proposal is the integration of 3d graphics with video material. Despite advances in 3d graphics hardware, virtual realities tend to be rather simple and cartoon-like in appearance; so we believe video imagery is needed to make virtual realities more compelling visually.

The problem can be stated as follows: 3d imagery is generated so that it responds to changes in the user's visual perspective. A video source, such as a VCR or laser disc, provides a video signal which is overlaid on a "video surface" appearing in the 3d imagery. For simplicity we assume that the video surface is rectangular (in world coordinates) and of the same aspect ratio as the video signal. However, because the user may not be directly in front of the surface, the surface may appear skewed. Also the surface may be fully or partially hidden by other objects. Thus the video signal must be transformed, and possibly clipped, in order to correctly fit on the video surface. The steps in this procedure are shown in Figure 1.

At the University of Geneva we are interested in exploring video and 3d graphics integration and applying our earlier experiences with multimedia, active objects and groupware. In order to experiment with video / 3d graphics integration we wanted an application domain with a rich supply of visual material. This led to our interest in the virtual museum.

Presently we are designing a prototype virtual museum which is depicted in Figure 2. Hardware components are represented by rectangles, processes by circles (which may be implemented in hardware, open circle, or software, shaded circle), arrows represent inter-component data flow.

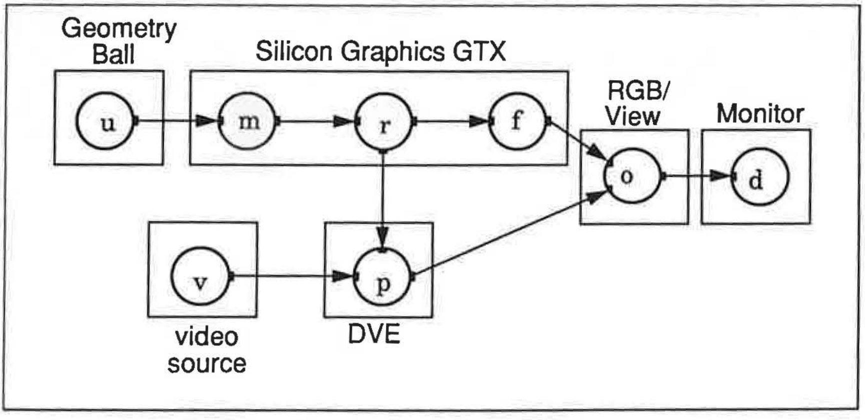

Figure 2 System Components

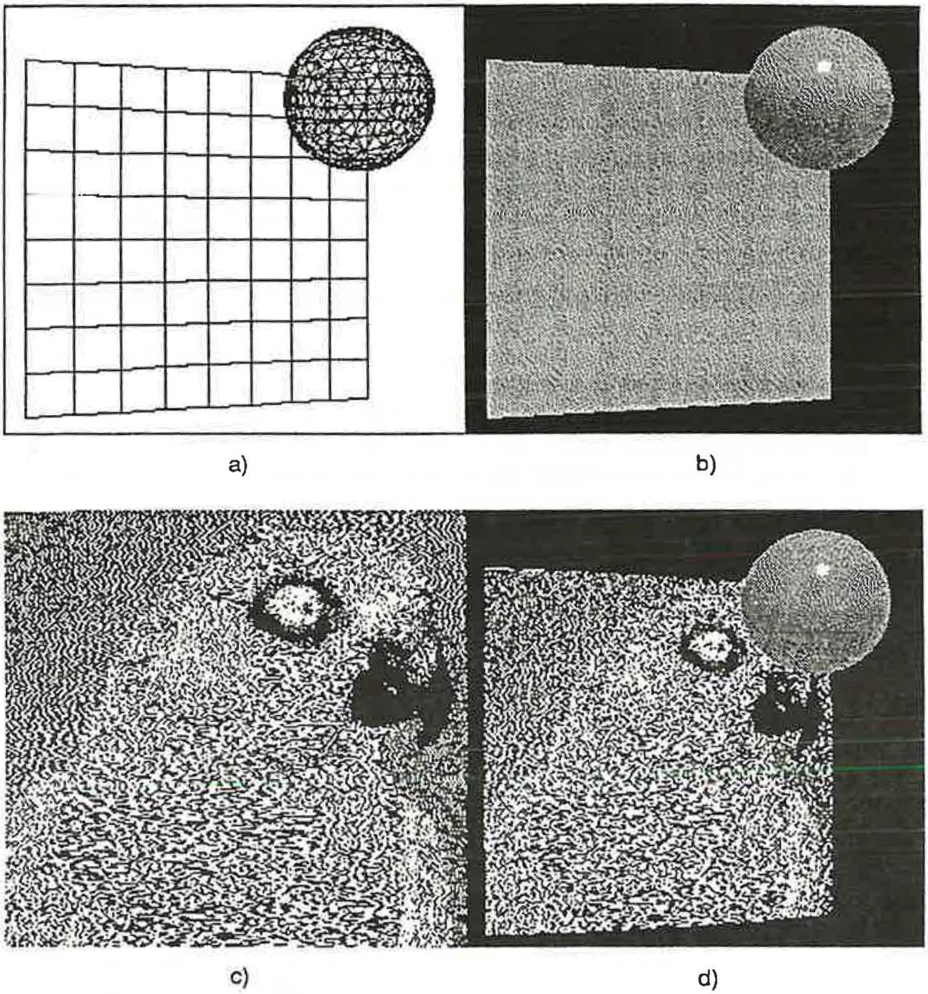

Figure 1 Part of a 3d model is shown before (a) and after (b) rendering. The model consists of a rectangular grid, which appears skewed because of perspective, and an occluding sphere. A frame from a video signal (c) is mapped onto the rectangular "video surface" (d).

The processes include:

- u – user input. The GeometryBall is a joystick-like device with 6 degrees of freedom (3 translational and 3 rotational). This allows the user to navigate in 3 dimensional space.
- m – model. The model includes the surface geometry of the virtual museum, shading attributes, light sources, video surfaces, and the user's current position and orientation (which is updated as values are received from the GeometryBall).
- r – renderer. The renderer shades the 3d model and writes a digital representation of the current view in the framebuffer. It also determines the perspective transformation needed by any visible and active video surfaces and passes this to the DVE. The model and renderer are implemented on a graphics workstation.
- f – framebuffer. This high-resolution (1280 x 1024 x 24) framebuffer produces a RGB signal.
- v – video source. A standard computer-controllable video source such as a laser disc. It produces a low-resolution composite video signal (NTSC).
- p – perspective transformation. The DVE ("digital video effects") unit applies a perspective transformation to the incoming video signal, producing a new video signal.
- o – video overlay. The RGB/View merges the high resolution RGB signal coming from the framebuffer with the composite video signal. Its output is high resolution RGB.
- d – display. The merged RGB signal is displayed on a 19" color monitor.

As described above, the prototype perhaps would not be termed a virtual reality since the display is not stereoscopic. However, this is primarily a matter of expense; essentially duplicating the hardware (creating one "channel" for each eye) and replacing the monitors with a head-mounted stereo display is all that is needed to obtain a virtual reality interface.

6. Concluding Remarks

The advantages of a virtual museum are many. First, it offers economic access to the artifacts to many persons and to those, such as the physically disabled, for whom it might not be possible otherwise. Second, it is safe for the artifacts. Third, it allows each artifact to be displayed. Fourth, the setting can be approximately chosen or even specially composed. Fifth, people can combine, operate on and generally "play" with the artifacts. Finally, it can show to people scenes which otherwise could only be imagined.

It is also worthwhile to ponder the disadvantages. First, real artifacts should be more impressive than their audiovisual representation. Unfortunately, for security reasons, real artifacts are becoming increasingly remote and so appearing less real. Second, real settings should be more exciting. Most settings, however, are simulated and not exactly "real." Display of virtual Egyptian artifacts in a virtual Egyptian setting may be more realistic than the display of real artifacts in a showroom in Paris or London.

Third, visiting a real museum is often exciting because of other people being there. Nothing prevents, however, virtual museums from being experienced by a group. A class or family could collectively explore a virtual museum and interact with other visitors. Finally, active participation is optional and not destructive. A person wishing a passive view can leave operations to a virtual tour guide.

The question remains of who should get involved in providing such services. The entertainment industry and technology companies will surely get involved; they have the technological knowhow and financial strength. Museums, however, have the raw data and should not just give them away. They should be active participants in such an operation – not only to obtain extra funds and retain their clientele, but mostly to assure proper historical and scientific control of what is displayed. People should see not what entertainers would like them to see (intellectual sugar), not what the computer people can make them see (surface quality), but what artists and historians and archeologists would like them to imagine.

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