Designing a virtual museum within a museum

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1 Abstract

A virtual environment system installed within a real museum can offer a number of advantages, which are discussed in this paper: overcoming the lack of exhibition space, responding to the need for interaction with certain exhibits, affording easy transfer of exhibitions to remote sites. This paper also presents an approach towards designing and developing a virtual reality museum comprising ten different museums. The processes of digitisation, architectural design and exhibit presentation are outlined and points of particular importance are explained. Exhibits from real world museums have been digitised and integrated in this VE.

Keywords: Virtual Reality, Cultural Heritage, Virtual Architecture.

2 Introduction

The concept of a museum without walls was firstly introduced by Malreaux [10], as a new kind of environment for viewing and presenting art. With the technological means of his era, Malreaux imagined a museum without walls comprising mainly of photographs, which could be included in printed media. The term “Virtual Museum” was coined by Tsichritzis and Gibbs in [14] where they describe the concept of a virtual museum and the technologies which are essential for realising it.

Museums host exhibitions for the purpose of disseminating certain messages to their visitors. These messages are being manifested through the form and arrangement of exhibited objects within the museum environment. Scientific and cultural information communicated by museum exhibitions can be enhanced by complementing plain exhibit presentation with additional media and by providing multisensory experiences [1, 15].

In recent years, multimedia techniques have been widely used for enhancing users' experience and attracting more visitors to museums, as well as for providing a new means for communicating their content and consequently information. Most modern museums offer multimedia info-kiosks, where visitors can get information regarding the museum's collections, special exhibitions, and other cultural activities. In some cases there is an option for a multimedia tour of the museum, where the visitor may 'preview' the museum content. 3D graphics and simulation technologies also offer the possibility of reconstructing lost or partially preserved objects and enabling visitors to experience an approximation of the original artefact.

Additionally, the emergence of the World Wide Web provided the infrastructure for making museums available at a global level, since an on-line exhibition is accessible from almost anywhere in the world at any time.

The integration of such enhancements has certain important implications on the process of creating a museum as well as on the perceived experience. As a result, a series of new issues regarding the design and development of such multimedia, multisensory exhibition environments arise. In an earlier paper [4], we addressed general issues concerning the design and development of a Virtual Museum, accessible either through the Web or locally. This paper considers the design of a 3D virtual museum environment to be installed within a museum. It particularly focuses on the usefulness of such a system within a real museum and on other specific issues identified during its development.

The project "Virtual Museums" was sponsored by the Greek General Secretariat of Research and Technology and has focussed on the development of a Virtual Environment that would enable museums' visitors to view and manipulate 3D exhibits. This environment could be made available to the public either locally or through the Internet, but this paper covers the former aspect. Ten real museums, which exist in Athens, participated in the project and provided 2D and/or 3D exhibits. This environment could be made available to the public either locally or through the Internet, but this paper covers the former aspect. Ten real museums, which exist in Athens, participated in the project and provided 2D and/or 3D content to be digitised and presented within the virtual environment (VE). The number of participating museums as well as the diversity of their content required a generalised strategy that catered for different museum presentation needs and allowed for future expansion.

Furthermore, several experimental evaluations were needed for determining the best configuration of virtual reality devices that would enable users to navigate within the virtual environment and manipulate exhibits in an effective and intuitive manner.

The first section of the paper discusses the possible advantages from incorporating a Virtual Museum presentation within the context of a real museum. Consequently, our approach to designing and implementing the locally executed Virtual Reality Museum is presented. Finally, the results of an experimental evaluation of three input devices as a means for navigating and manipulating exhibits are briefly mentioned.

3 Introducing a virtual museum within a real museum

The main objective of the 'Virtual Museums' project was to create a virtual environment (VE) for enhancing the experience of visiting a museum by affording viewing and manipulation of
certain exhibits. This VE would be installed within the participating real museums and experienced locally, while a specially developed application would enable remote visitors to search and view exhibits' resources (3D objects, images, video, etc.) through the Internet. Software tools necessary for the museums' supervisors to index, categorise and retrieve objects were also created.

Multimedia, 3D graphics and virtual reality (VR) technologies have been used in many cases [8,9] for creating an enhanced, on-line version of an original museum. It is however understood that a “virtual museum” is not necessarily limited into being a simulation of a real, existing museum. Such systems can also be utilised for augmenting the visitor's experience within the real museum environment [5,6,7,13]. It is considered essential, at his point, to discuss the reasons, which justify the introduction of a VE, which comprises museum content, within the space of the museum itself.

a) **Limited space**: Most museums display a fraction of the exhibits that they own, since exhibition space is always limited. Some objects may be too fragile or valuable for exhibition. Stored objects can be effectively displayed by means of a VR presentation, installed within the museum.

b) **Enliven exhibit presentations**: Although a simple multimedia presentation can be used for displaying stored content, a VE system affords a more vivid and realistic experience. Exhibits can be interactively observed from different viewpoints or even manipulated. It has to be stressed however, that the nature and individual characteristics of an exhibit (painting, photography, 3D object, etc) largely dictate the ideal technology that should be used for displaying it in a digital form.

c) **Multisensory experience**: Successful orchestration of the visual and auditory output of the system with the input accepted by it, interaction and navigation within the VE, all may result in certain kinaesthetic information being communicated to the museum visitor. Haptic feedback technology may also enable visitors to touch and feel valuable objects, or may let people with vision problems sense an exhibit.

d) **Virtual Heritage visualisation**: a VE system affords visitors the possibility to view a simulation of important objects, buildings or environments, which have been constructed at a much earlier point in time; these environments may either:

- no longer exist today
- be somehow damaged and in need of reconstruction or
- can not be easily experienced, either because they exist at a remote site or because their condition does not allow for their interior to be navigated.

e) **Mobile exhibition**: the digitised content of a museum may be experienced in a realistic manner via a mobile VE system, which can be easily transported to any exhibition site or remote location. This fact may give a chance to a wider audience to view important exhibitions without having to travel far.

f) **Navigational aid**: Some museums are quite vast and, in some cases, visitors may only be interested in particular exhibits, which exist at certain points within the museum. Instead of physically traversing the distances amongst these objects, visitors may view the desired exhibits from within the VR-equipped system. This is particularly important for visitors with accessibility problems.

g) **Visualization of hazardous sites**: a VE system is a secure way of providing the experience of visiting an environment, which may be too difficult or too dangerous to physically visit (e.g. inside a volcano or on the mountains of Mars).

Finally, a VE system may support the process of designing an exhibition. It may be used either during the iterative design process, as a means of evaluation, or after the completion of the design, as a means of communicating the result.

4 The design of the virtual museum - Museums' requirement analysis

The design of the virtual museum followed a task analysis methodology; proposed by Parent [11]. For each of the 10 museums a profile of its users was drawn, where attributes such as their language and their profession (i.e. student, researcher, etc.) were recorded. Accordingly, visitors were categorised in three groups: researchers, students and general public. Researchers were highly motivated, usually computer literate individuals who would actively navigate through content and would usually require direct access to exhibits. On the other hand, a large percentage of students (primary or high school) had some experience with computers and/or game consoles but they were often bored and had to be somehow impressed for gaining their attention. The general public group comprised all other museum visitors that did not belong to one of the other two groups.

An outline of the museums characteristics, taking into account the museum's aim, special needs, existing infrastructure, etc., was also identified. Consequently a task analysis profile was composed, which included issues such as the rationale for the design of each sector of the virtual museum as well as the overall environment, the activities it would support and the requirements for storage and retrieval. Finally, design requirements for participants and for the target application were identified. These requirements determined the manner in which the museum content was organised and categorised and also informed the creative phase of the design at all times.

5 Virtual Museum development

The development of the Virtual Museum consisted of four main tasks. The first was the digitisation of exhibits to be presented; the second was the development of the Virtual Museum
environmental elements, within which the exhibits would be spatially arranged and presented; the third was the actual integration of exhibits within the virtual space; finally the manner in which participants navigated within the VE and interacted with its elements was implemented.

The first three phases progressed in parallel for some time. Once the layout of a museum's hall or foyer was sketched, the model was constructed by means of 3D modelling techniques and iterative design was applied till the environment matched the requirements. Consequently exhibits were added to the rooms and presentation modifications took place. In order to aid the process of manipulating the objects and their various versions (low, medium or high resolution, 2d or 3d) a database was created where all museum resources were stored.

Once the museum environment was completed, the programmers' team implemented the necessary 3D interaction into the application, in accordance with the requirements analysis. Behaviours and actions were programmed for supporting appropriate navigation modes within the VE and for affording certain modes of interactive manipulation of exhibits.

Since the requirements differ among the ten museums, two different versions of the system have been created. These versions differ in terms of the peripherals supported:

- In the lower-end desktop version of the system, a monitor accompanied by a pair of shutter glasses are used as devices providing stereo display and a Magellan Space Mouse is used as a 6-DOF input device. This version is expected to be installed in museums, where peripherals have to be able to withstand frequent, everyday use by visitors. An experiment has also been conducted for the purpose of evaluating the efficiency of three input devices (mouse, joystick, Magellan Space Mouse) for navigating and interacting in the VE. The results of this experiment are briefly reported at the last section of this paper.

- In the high-end version, users wear a Head Mounted Display and a Cyberglove, mounted with trackers, which monitor their movements/gestures. This is a version intended for researchers, since these peripherals are more fragile and frequent use can easily damage them.

### 5.1 Exhibit digitisation

For the digitisation of 2D exhibits, high quality photographs were used. The digitisation of 3D exhibits involved one of the following three approaches: 3D photography, 3D scanning or 3D modelling. Each approach had its advantages and disadvantages and the selection of the most appropriate approach, in each case, depended on the exhibit and the requirements set for its presentation.

3D photography was the easiest and most straightforward of the three methods. The object was first captured by the camera as a set of photographs, which were then imported in proprietary software and stitched together. Finally a three dimensional description of the object including the images mapped on its surfaces was deducted and exported in a format compatible with the VR software used for the virtual museum development. This method was not the best in terms of quality and accuracy of depiction. It was more convenient however, for digitising objects when the surface qualities or the size of the exhibit did not allow for 3D scanning techniques or when the object was difficult to model.

3D scanning was used in most objects where quality and detail of the representation was essential and where their surface properties allowed for laser scanning. For example, most of the ancient objects were scanned via this method, since the need for a precise reproduction of the original artefact could not be fulfilled by the other two methods.

Finally, when the original object mainly comprised of geometrical forms, it was feasible to produce a precise 3D representation by means of existing 3D modelling tools (as in the case of a telescope or a machine). These methods allowed for creating hierarchical models, which afford more flexible manipulation of individual smaller components that the object comprised of. For example, a model of a machine may help a participant visualise the way that it works and afford certain modifications on its operation.

### 5.2 Environmental design

The museum message is communicated by an exhibition to individual participants through museum exhibits. Messages may be directly communicated via the content of exhibits but they are also influenced by:

- the way that exhibits are individually positioned in space
- the way that exhibits are grouped for the need of an exhibition and the consequent relation of each exhibit to the general organisation of the exhibition.

Therefore, the spatial organisation of exhibits within the virtual museum has a significant effect on the message communicated to participants via this exhibition.

It can be suggested that environmental characteristics of the virtual museum, such as lighting, positioning and orientation of exhibits and physical structure of exhibition spaces, may determine the behaviour of museum visitors when navigating or viewing an exhibition within a museum and their will to view certain exhibits [12]. It is therefore understood that the environmental design of the museum significantly affects the message communicated to visitors as well as their behaviour within the virtual museum and consequently the degree to which target and user requirements are accommodated.

All aspects of the virtual museum experience have been organised so as to add to the participant’s knowledge acquisition and entertainment. It has to be stressed, however, that the design of the “virtual” exhibitions in the ten museums participating in this project mainly focuses on the educational aspect of the museum experience, rather than the aesthetic one.

Emphasis has been given on the functionality of the environment regarding user navigation and content presentation. The manner in which space was designed within
the museum aimed at aiding the participant into navigating within the VE, while maintaining a sense of orientation provided by appropriately designed environmental information. The utilisation of architectural knowledge has proved invaluable in enhancing the participant’s environmental knowledge and in directing participant attention towards certain points or messages within the exhibition space.

The final virtual museum environment does not resemble a realistic representation of museum building. Indeed, it is argued that while the use of realistic metaphorical representations may allow for transfer of knowledge and skills involved in everyday activities, the use of realistic environmental elements may limit the potential of VEs for creating novel forms, environments and situations. Therefore, the approach followed in designing the museum maintained certain generic environmental elements of the real world and attempted to investigate more abstract, non-realistic forms and elements which are thought to improve the effectiveness and impact of the exhibition. In certain cases, however, a simplified simulation of a realistic setting has been considered as a more appropriate approach and has been adopted accordingly (e.g., the museum of Zoology).

Regarding the spatial characteristics of the designed environment, which have dictated the form and properties of all environmental elements, certain significant issues are discussed below.

Traversing within certain paths in the museum environment is considered essential for the purpose of enhancing the generation of cognitive maps of this environment by participants. In the meantime, movement within these paths is aided by an automatic escalator-like function, which rids participants of the effort to manoeuvre via a narrow longitudinal space. Space in the virtual museum may, at certain points, be discontinuous. A participant may teleport from one position within a VE to a remote position within the same VE when traversing between these two positions is not considered essential.

Since gravity has not been implemented, the sense of vertical/horizontal in this VE depends on environmental cues, which may enhance the sense of orientation [2]. Such cues have been carefully integrated in the environmental design (red horizon, textual signs, etc.)

The 10 museums that the designed VE consists of, have been organised into 4 categories according to their content:

- **Human-centred museums** (Anthropology, Forensic Science, Hygiene)
- **Historical/archaeological museums** (Goulandris Museum of Cycladic Art, Archaeological Museum of the Department of Philosophy - University of Athens, Museum of History of the Athens University)
- **Museums of the Earth** (Mineralogy, Geology)
- **Museums of the Flora and Fauna** (Botanical, Zoology)

The spatial design of the museum has been dictated by these categories as well as categorisation of exhibits within each individual museum according to the requirements provided by museum organisers as well as their selection of particular exhibits for display. The spatial organisation of each exhibition is also determined by the way activities are organised within each museum and this fact depends on the aim and objectives of each individual exhibition.

Several other factors also determine the form of each spatial entity within the museum:

- The nature, size, and number of exhibits it includes.
- The specific needs for each exhibit category.
- The way that the museum spaces are interconnected with the overall museum complex and its sub-domains.
- The 3D navigation technique used in the VE.
The method of viewing a set of exhibits.

The overall museum complex expands in three dimensions, the depth of the hierarchical structure of the complex corresponding to the dimension of “height”. The structure of the museum mainly comprises of three different types of foyer, which accommodate the distribution of movement within the museum complex:

- entrance hall
- museum-category foyer and
- museum foyer.

The participant enters the overall museum complex at a hall, which has a centralised form. Since the application is initially designed for a limited number of participants (1-2) this hall as well as all foyer spaces are not very large but simply serve as a spaces for distributing movement towards each of the 4 categories of museums. Each category corresponds to a foyer, which further distributes the navigating participant to each of the museums. As participants look up towards the museum complex from within the entrance hall, which has a semi-transparent top surface, they are able to view the structure of the whole museum and be aware of what to expect as they make their way into this structure.

Navigation between the entrance halls and foyer is performed via paths, which have a longitudinal cylindrical shape and a square section. Repetitive frame-objects are positioned along these paths for enhancing the sense of movement and providing a feedback on the distance traversed while moving along the path [3].

The use of teleportation has been adopted at “higher” levels of the museum structure, for reducing movement and facilitating navigation within the VE. This is also considered essential for affording the inclusion of more exhibition halls in the future, without the necessity of significantly changing the spatial design of each museum.

At the individual museum level, participants enter each museum’s foyer and may navigate towards a number of transitional spaces from where they have a choice of paths or halls to follow in order to view parts of the exhibition. Each path or hall corresponds to a group of exhibits. At the end of
these paths and halls there is a portal, which teleports participants back to the transitional space where they can make their next navigational decision through the museum content.

5.3 Exhibit presentation

The museum message is communicated via the exhibition and its exhibits to individual museum visitors. It is understood that visitors perceive this message in a subjective manner, according to their interests, knowledge and imagination. A number of issues regarding the presentation of exhibits may have an impact on messages communicated to museum's visitors:

- the content of each individual exhibit,
- the manner in which the exhibit captures the visitor's attention,
- the position of the exhibit within the exhibition.

Depending on the museum's nature/characteristics different approaches have been explored in presenting exhibits. In some cases presentation may have attempted to resemble real world museums, in the sense that a neutral spatial context is provided wherein significant objects are exhibited. However, visitors are able to perform tasks that they would not be able to carry out in the real museum. They can move or rotate objects in order to inspect them. In some cases virtual reality technology has been utilised for constructing an interactively experienced diorama for presenting the original exhibits more vividly.

The museums of Flora and Fauna contain exhibits that are better presented in an environment that looks like their natural surroundings. For example, one of the exhibits of the zoology museum was a penguin.

Figure 7: Photograph and Diorama reproduction of the penguin model

In the original exhibition the penguin was presented as one object rather than an animal in its natural surroundings. The visitor had to visualise (using knowledge acquired from other sources, i.e. documentaries, school books, museum guides) the penguin living in its natural environment. This limitation of the real world museum could be overcome in the virtual reality museum by creating a diorama. In this exhibition the visitor enters a hall where the penguin is presented on an iceberg. The visitor can view the penguin, while the sound of waves splashing against the iceberg is heard.

Figure 8: Views of exhibits in the Goulandris Museum of Cycladic Art and the Forensic Science museum halls

Although in the current version of the virtual environment visitors cannot really interact with the penguin, as they would with a real world animal, the experience is yet more vivid than the one afforded by the original exhibition.

Finally, the addition of explanations, in the form of text or narration has been used for enhancing the user's experience and for providing necessary informational cues.
6 Evaluation

For an experimental testing of input devices use of with the particular VE system, the setting of the museum of criminology was used. The setup of the experiment employed a standard PC running the virtual reality application equipped with shutter glasses (as will be the case with the system setup at the museums' space), and three different input devices: a standard mouse, a Joystick and a Magellan mouse. Each of the participants used each one of the input devices for navigation and object manipulation, in a random order. A questionnaire and a video recording of sessions with each participant were used as means for recording the experience. Additionally an informal chat has proved useful for eliciting feedback regarding general issues of system usability and navigational behaviour.

A number of conclusions have been drawn from this experiment and these are very briefly reported below. Although we anticipated that users would find the Magellan mouse easier to use in a virtual environment than the common 2d-mouse, this was not the case. Users easily understood the notion of 'click and mouse move' for navigating. Furthermore, users found the Magellan’s responsiveness problematic. Users also had problems with navigating although their 6DOF movement had already been restricted for avoiding loss of orientation. A lot of the users expressed negative comments on the fact that they were able to both fly and look up and down. They felt that one of the two moves was sufficient for navigation, preferably that of flying. They also felt that a “walking” mode of navigation, where users' movement would follow the surface's slope, would be helpful, since they sometimes moved too low and collided with the floor.

7 Concluding remarks

New technology offers a great opportunity for museums to make their exhibitions available to more people in ways that was not feasible before. Although a virtual exhibition cannot replace or diminish the value of experiencing the original exhibits, there are cases where it can enhance the visitor's experience and draw new guests to museums.

In our approach, ten museums with exhibits that vary from archaeological to geological and from hygiene to forensic have been integrated within the context of a virtual environment. Such a system offers the visitor the possibility to view a selection of each museum's collections without having to travel. It is important to stress the significance of using a VE system as a means of exhibiting the content of a museum in another remote exhibition space, since it may afford a larger number of people the possibility of experiencing important exhibitions without having to travel far and may also lead to important collaborations amongst museums worldwide and consequently to enhancing the communication of knowledge and culture internationally.

While designing and implementing such a system, a great effort should be put on the spatial aspect of the VE, since this has a significant impact on the message communicated to visitors and on their behaviour within the VE. Finally, we should emphasize the significance of virtual reality techniques in helping museums' guests visualise exhibits in a manner that is not possible in a real museum.

We are currently investigating different methods for presenting exhibits to virtual museum guests. In particular, we are looking into creating fully interactive dioramas, where exhibits will have self-awareness and guests will be able to interact with them.

8 References

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