An approach to designing and implementing virtual museums

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Abstract. The current paper describes an approach to designing and implementing a virtual environment comprising ten different museums. The number of museums as well as the variety of their exhibits lead to the adoption of a generalised strategy that catered for all museum presentation needs and allowed for future expansion. Furthermore, the system architecture supports the delivery of multimedia content either over the Internet or via a local immersive virtual reality installation.

Keywords: virtual reality, virtual museum, digital exhibit

1. Virtual Museums

An exhibition is a complex informational system and an organised event through which society and time interact in a predetermined museum space. The message of a museum is the medium through which the museum communicates information, produced by its collections, which consequently creates new information. The message of a museum is manifested

through the form of the exhibited object and this manifestation takes place within a museum environment. The museum object and the collection are sources of two kinds of information: scientific and cultural. The museums, which participate in this project, belong to both categories.

This paper documents part of a research project titled: "Virtual Museums"[1]. This project aims at creating a locally executed virtual reality environment as well as enabling participants to visit this museum via the web for the purpose of viewing and manipulating the museum's 3D exhibits. A number of real museums participated in the project and provided 2D or 3D content to be digitised and included in a virtual museum.

Malreaux (1953) has introduced the concept of museum without walls, as the context for exhibiting which became possible with the arrival of mechanical reproduction techniques and the consequent ability to reproduce images. This was a new kind of environment for viewing and presenting art. According to the technology of his era, Malreaux imagined a museum without walls comprising mainly of photographs, which could be included in printed media. Tsichritzis & Gibbs (1991) introduced the concept of virtual museums. Current IT and communication technologies (digitisation, internet, hypermedia and virtual reality) allow for the use of a wider selection of media for reproducing and exhibiting objects. It may also be suggested that via the WWW, a museum opens up to a global level of access. An on-line exhibition is accessible from anywhere in the world at any time. Thus, an on-line museum experience can be seen as a spatial experience of a personal as well as public character at the same time.

The design of the "Virtual Museum" involved an analytical phase that aimed at creating the theoretical basis for the design of activities taking place in the virtual museum, the setting where these activities take place and the rules that dictate interaction amongst the elements of this environment.

2. Database design

One of the key issues during the application design stage was the use of a central information repository containing all resources regarding the virtual exhibits and facilitating access to it, both from the web and the locally executed application. To this end, a database was designed and implemented, to hold the location for each of the exhibit's resources as well as other useful information about the museums, the exhibits and their categorization. Figure 1 illustrates the database schema.

The museum database contains both textual and numeric data as well as multimedia content. Information whose size is relatively small, such as short text strings, is kept in the database, in order to facilitate efficient storage and ensure augmented search capabilities. On the other hand, larger, non-searchable structures such as images, sound, video, 3D models and text files are stored in the file system and only their position is kept in the database. All the fields having the prefix "path" are text strings that contain the UNC (Universal Naming Convention) path of the file, for example "\\oceanis\museums\data\Goulandri\ex1\photos\image1.gif",

[1] The "Virtual Museums" project is sponsored by the Greek General Secretariat of Research and Technology within the EPET II Framework.

while fields with the prefix "url" are text strings that contain the URL (Universal Resource Locator) of the file, for example "http://www2.mm.di.uoa.gr/ Goulandri/ex1/photos/ image1.gif". The former are mainly used to access resources in a local immersive environment, whereas the latter are used for WWW content dissemination.

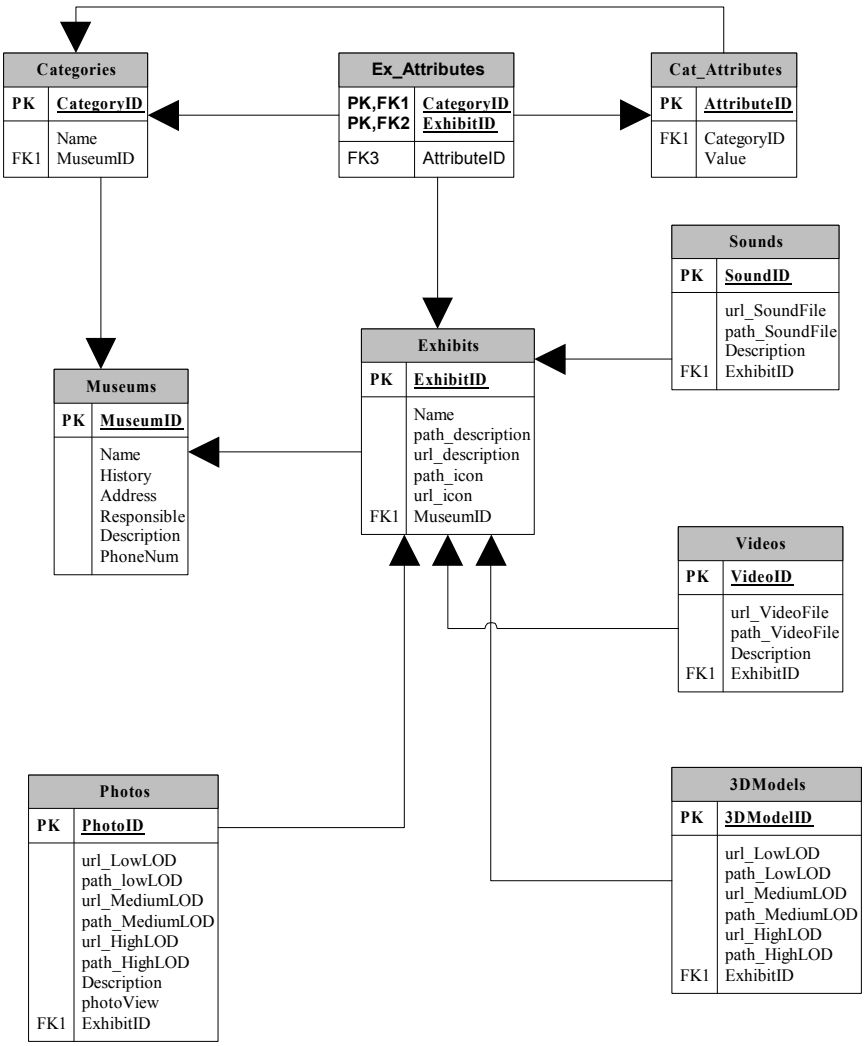

Figure 1: IDEF1.x diagram of the VR museums database

The database schema allows for the effortless addition of new museums with different focuses. The database stores useful information about the museums themselves, such as the museum name, address and phone number and the path of the text files containing its description and history. It also stores all the necessary information concerning the virtual exhibits of the museums. The position of photographs, videos, sounds and 3d models is a part of this information, kept in a different table for each type of data structures. In addition, an exhibit has a name and a text file containing its description.

The database application administrator can append new categories and their attributes to describe the museums informational content and classify its exhibits in groups of similar characteristics. For instance, if a new museum with archaeological content is added, then the administrator can define categories such as the chronological era of the article and their respective attributes to be Stone or Bronze Age. These categories facilitate searching and

classification of exhibits enabling participants to locate exhibits with similar attributes and virtual reality content authors to formulate thematic collections.

As shown in the diagram, the database can accommodate all information needed for the virtual reality presentation, such as 3D models and images in various levels of detail and multimedia information (sounds, video). Images and 3D models are stored in three levels of detail, low, medium and high whose URL and UNC path are prefixed with “low”, “medium” and “high” respectively. Moreover, the database contains the necessary fields to produce web-based presentations of the museums. The database does not contain information regarding virtual reality environment set up details, or details for the web presentation, since these are not correlated.

3. Database management

A database management application serves the need to keep the database up-to-date and consistent. The application simplifies the management of museums' collections, allows for the insertion of new exhibits in the database, and ensures the availability of the exhibits' resources by checking invalid links to new or existent resources. The database management application may also facilitate database management by invoking administrator-specified filters that automatically fill-in specific fields. For instance, when a 3D model is defined for an object, in order to be used in a VR-tour, an external filter may be invoked to automatically produce GIF images that will be used within the Web-based presentation. Such translations are generally expensive to be performed on-the-fly and therefore invoking them once per resource is a more appropriate solution.

The application can assist the database administrator in performing various actions. The administrator can easily insert, update or delete museums, exhibits and categories through a user-friendly interface and without having to perform the changes on the database itself. It also offers search capabilities in order to facilitate the update of the resources of specific exhibits. The user may find one or more virtual exhibits in the database through their name or through their attributes and then process the search result. In addition, the application offers the capability of displaying to the user an image and a description of each of the desired exhibits, as shown in figure 2.

Figure 2: A dialog box from the database management application

The database management application is designed to allow only to the authorized users to exploit its full capabilities, as unauthorized modifications of the content of the database could have a serious impact both to the virtual reality environment and the web presentation. The administrator is required to provide a password in order to be able to perform all the actions that alter the database, whereas the display and search functions can be performed by all users.

4. Web presentation

The web presentation is formulated dynamically, based on the visitor's requests. Visitors are presented with some general information about the museum, and may then search among the museum's exhibits to create their own "exhibit collections". An application running on the web server accesses the database in order to select the relevant articles and creates the respective HTML pages, which are shown to the participant. The site administrator may also create pre-defined collections, offering visitors the capability of a "guided tour".

5. The design of the virtual museum

The design of the "Virtual Museum" has adopted the model introduced by Parent (1999). Participant profiles and needs as well as target requirements were firstly identified for the whole and for each museum individually, according to the information provided by these museums. Consequently, design requirements for participants and for the target application were identified and these determined the way in which the organisation of the content and the creative phase of the design evolved. Finally, the virtual environment (VE) was developed.

This development mainly involved the digitisation process for the 2D and 3D objects which are exhibited, the creation of 3D models for the environmental design of the museum complex, the positioning of the content in certain positions within the exhibition space and the design and development of the manner in which participants will interact and navigate within the virtual museum.

All aspects of the museum experience have been organised so as to add to the participant's knowledge acquisition and entertainment. Several factors may affect the behaviour of a museum visitor when navigating or viewing an exhibition within a museum: lighting, positioning and orientation of exhibits and physical structure of exhibition spaces. The museum message is being perceived by each individual participant in a subjective manner, according to her interests, knowledge and imagination, and is communicated via the exhibition to her through the museum objects/exhibits. Apart from the meaning of each individual exhibit, messages communicated to the participant are also depended on:

- the way that exhibits are positioned
- how each exhibit can capture the attention of the participant
- the relation of each exhibit to the general organisation of the exhibition.

5.1 The spatial design of the virtual museum

A significant issue concerning the spatial design of the virtual museum relates to the level of realism that characterises its environmental elements. The designed VE is required to be effective and to be used in an instinctive way while the resources of the system ought to be

utilised in the best possible manner. This paper argues 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 limits the potential of VEs for creating novel forms, environments and situations. Therefore, the designed museum maintains certain generic environmental elements of the real world and attempts to investigate non-realistic forms and environments that are thought to improve the effectiveness of the exhibition environments. 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).

In order to identify the conditions, which will dictate the design of the environmental aspects in virtual museum, certain issues relating to the inherent characteristics of space in virtual environments have been taken into account:

- Space in a VE may be discontinuous (Charitos & Bridges, 1997). A participant is able to teleport from one position within a VE to a remote position within the same VE or among different VEs. If two VEs are connected in this manner, they are not spatially related to each other in terms of a three-dimensional, Cartesian context. They could be anywhere and indeed it becomes irrelevant where they are in relation to each other. In this sense, the structure of spaces within a VE can be partly hypertextual in nature.
- Physical laws, which may dictate the dynamic, spatio-temporal nature of an environment do not necessarily apply to VEs. Such constraints are only determined by the specific task requirements of the VE. In the case of the virtual museum, gravity and friction are not seen as absolutely essential characteristics and will not be implemented. Indeed the lack of gravity and consequent fly-through navigation mode is seen as more appropriate for a VE that expands in three dimensions.
- A VE does not necessarily have scale consistency. It is possible to alter the scale of the environment, in relation to the participant. It could be argued that the sense of scale in a VE is relative to its spatial context and also dependent on the existence of certain environmental elements.
- The sense of vertical/horizontal in a VE depends on the implementation of gravity or in environmental cues, which may enhance the sense of orientation (Charitos, 1998).
- When a participant is being teleported, a new environment is being downloaded to the system and the download time cannot be mapped to a certain translation of the participant's viewpoint in the space of the VE. In this sense there may be a certain temporal discontinuity in the experience of a VE.

The way that the exhibits are positioned within the virtual museum is determined by the way that these objects are organised in each exhibition. The spatial organisation of an exhibition is determined by the way that activities are organised within each museum and this fact depends on the aim and objectives of each individual exhibition. 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.

5.2 The structure of space in the virtual museum

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 (Gouladris 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 overall structure of the museum mainly comprises 3 different types of foyer, which accommodate the distribution of movement within the museum complex:

1. entrance hall
2. museum-category foyer and
3. museum foyer.

These foyer-spaces are connected via paths, which have a longitudinal cylindrical shape and a hexagonal section. Repetitive frame-objects are positioned across these paths for enhancing the sense of movement and providing a feedback on the distance traversed while moving along the path (Charitos, 1998).

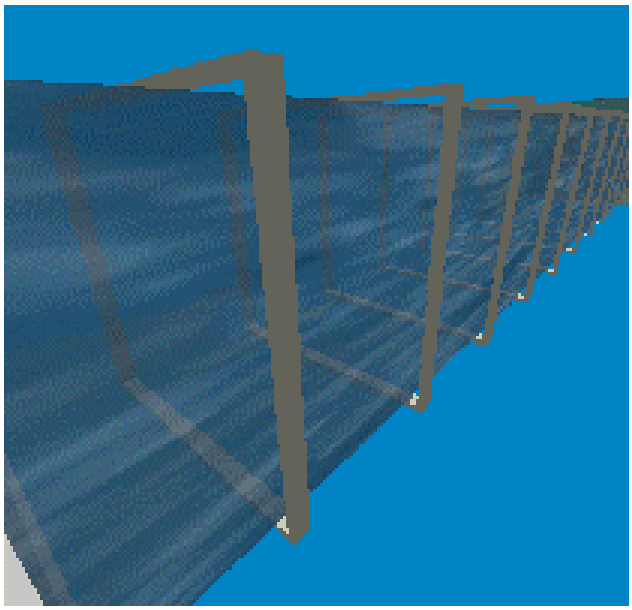

Figure 3: Image of a path

The overall museum complex expands in three dimensions, the depth of the hierarchical structure of the complex corresponding to the dimension of "height" (y axis). The participant enters from a hall, which has a centralised form. Since the application is initially designed for a limited number of participants (1-2) this hall is not large but simply serves as a space 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 hall, each museum-category foyer and each individual museum foyer is performed via paths. However, the use of teleportation has also been adopted for the purpose of reducing movement, thus facilitating navigation within the VE. Movement towards the exhibition halls in each museum is mainly done through teleportation. This

characteristic is 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's foyer. The participant can enter each hall from the museum's foyer or can navigate through all halls without re-entering the foyer by following a predetermined linear sequence.

Categorisation of exhibits and consequent organisation of spatial entities in each museum follows the requirements provided by museum organisers. The factors that determine the form of each museum hall are:

- The nature, size, and number of exhibits it includes.
- The specific needs for each exhibit category.
- The way that the museum halls 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 design of space within the museum environment has attempted to aid 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.

6. Future work

Currently, work has focussed on the implementation of the immersive, locally executed version of the virtual environment and on completing the laborious task of exhibit digitisation and database population. System evaluation will be carried out by means of two pilot applications, the first targeting the Internet community and the second addressing museum visitors. Once these pilot studies are concluded, research will continue to investigate the interaction between multiple users in the proposed virtual museum setting.

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