AN AUTHORING SYSTEM FOR THE AUTOMATIC GENERATION OF VIRTUAL EXHIBITIONS

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ABSTRACT
The use of virtual reality on the Web offers exciting opportunities in several application fields (e.g. cultural heritage, e-learning, e-commerce). Nevertheless, the adoption of such technology is not as widespread as one would expect. The main reasons can be found both in the difficulties for the development of virtual environments, which requires a collection of advanced skills and a variety of tasks, and in the limitations of current desktop virtual reality technologies which do not allow users for a comfortable navigation of the scenes. To overcome these problems, we propose an authoring system which enables authors without skills on 3D technologies to automatically generate their own virtual exhibitions. Moreover, to simplify the navigation within the scenes, a specific paradigm based on the concept of guided tour has been adopted in the generated exhibitions.

KEYWORDS
Authoring System, Automatic Generation, Virtual Reality, Web3D

1. INTRODUCTION
In the last years, thanks to the parallel availability of wide Internet bandwidth and powerful 3D graphic hardware for a broad range of personal computer users, some institutions have experimented communication initiatives that use 3D representations as an alternative or a complement to hypertextual ones.

Such experiences showed that in many contexts the 3D provides enough enhancements to justify the discard of traditional 2D metaphors. Encouraging results were found in e-commerce, where 3D allows users to get more information about the goods [Po3D], in entertainment, with complex videogames, and in edutainment, where many authors report enhancements in cognitive process using virtual environments. [Bre93, AlH00, CDP02]. In particular, desktop virtual reality seems to be one of the most appealing technologies for educational and cultural heritage advanced applications, both because users (and in particular students) are fascinated by the adoption of innovative solutions to convey cultural and educational information, and because Virtual Reality (VR) enables to discover the world through a sense and motion learning process, more natural for human beings than the symbolic-reconstructive way, such as writing [BBC00]. But, at the present, the diffusion of such technologies is limited by some factors. From a developer point of view, the creation of virtual environments is a challenging task. In fact, the majority of 3D worlds currently available on the net are created by 3D experts using professional but difficult tools, such as 3D
Studio Max [D3DS] or Maya [AWM], absolutely not suited for naïve authors. Only in recent times a limited number of tools propose simplified approaches, suitable for a broader range of users. For example, Outline3D [Out3D] allows to easily draw an interior starting from a plan and completing it with furniture taken from a comprehensive catalogue, using a drag & drop mechanism. The Virtual Exhibitor [VeX] is a tool that permits to construct and simulate in 3D an exhibition space where to place freely the exhibit items. However, these tools adopt a direct manipulation paradigm of 3D primitives, in order to correctly place and show the set of objects composing the virtual environment. This task can still be challenging for people unskilled about 3D concepts, limiting the adoption of such tools. A different approach is offered by the MATTHEW system [GrC99], which aims to be an easy-to-use visual authoring tool to help inexperienced users setting up an exhibition. However this tool helps the authors only on disposing in an optimal fashion the objects to show within an environment starting from its 2D map, without generating any resulting virtual scene.

From an end-user point of view, the main factor limiting the diffusion of virtual environments on the web is the difficulty with the orientation and navigation in a 3D space. Indeed the standard input devices for personal computers, such as mouse, touchpad or trackball are limited to two degree of freedom (X and Y axis), while the exploration of virtual environments requires, at least, four degree of freedom (2D pan, yaw and pitch). Moreover, current Web3D browsers offer hostile interfaces, which do not satisfactory support the users during navigation.

The aim to simplify the production and the use of meaningful virtual worlds has motivated us to develop an Authoring System, which allows an automatic generation of 3D virtual exhibitions using a user-friendly interface. The generated worlds include a navigational paradigm based on the guided tours, which simplifies the use of virtual exhibition by desktop end-users. Moreover, our system results general-purpose, because it is able to fit very well a large variety of domains, ranging from Cultural Heritage (development of virtual museums) to e-learning (as a Learning Content Management System) or e-commerce (development of virtual shops).

The paper is organized as follows. In section 2 we will present the proposed authoring system, its architecture, the underlying navigational paradigm, and the structure of the generated 3D exhibitions, while in section 3 we will show the system interfaces for both the authoring and the navigation of the virtual scenes.

2. THE AUTHORING SYSTEM FOR THE GENERATION OF VIRTUAL ENVIRONMENTS

We experienced that the adoption of direct manipulation interfaces for the development of virtual environments is not the best solution for naïve authors, because, even if such systems often support stunning features and allow a perfect placement of the objects, they have a very steep learning curve, discouraging potential unskilled users.

To overcome these problems, we have developed an easy-to-use authoring system for the generation of virtual exhibitions, which presents a form-based user interface. In order to define a virtual scene, an author selects some objects via a simple query (something like: “Create an exhibition where Author = Michelangelo and Type = sculptures”) and the engine of our system creates the customized virtual environment containing the required 3D objects. Such world is dynamically generated in VRML (the standard language for the description of 3D scenes on the web) [VRML], using the Java Server Pages [JSP] technology.

2.1 The System Architecture

The system was developed adopting a typical three-tiered schema, composed by:

1. Some clients, with a Web3D-capable browser;
2. A web-server, able to manage dynamic contents;
3. One or more database servers, equipped with relational DBMS

In order to obtain a portable, reusable and open-source tool, the system adopts the HTML for the user interfaces, VRML for the 3D scenarios and Java (with its related technologies) as programming language.
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Figure 1. The three-tiered system architecture

Figure 1 describes the architecture of the system and its typical usage. We suppose the existence of one or more databases containing the relevant objects to show in the scene, along with their appropriate descriptions and a link to their representations in VRML. As first task, an author defines, via a simple HTML form, a virtual exhibition containing a particular set of objects, selected from the databases. The web server, equipped with Apache and Tomcat, then processes the requests and generates a VRML file using Java Server Pages technology. Such file, containing the demanded 3D objects taken from a relational database, is then published on the web, in order to allow, afterwards, an end-user to navigate that virtual scene.

2.2 The Database Schema

To allow the greatest flexibility in the selection of the objects to show, it was fundamental to define a database schema containing as more information as possible.

To this aim, we implemented the Dublin Core (DC) [DCS] metadata schema. The DC is a core set of 15 semantic definitions for describing resources likely to be useful across a broad range of industries and disciplines. It was defined by the Dublin Core Metadata Initiative (DCMI), an organization instituted by the National Center for Supercomputer Application and the Online Computer Library Center. The DCMI is dedicated to “promoting the widespread adoption of interoperable metadata standards that enable more intelligent information discovery systems” [DCS]. The DC was successfully adopted by the Computer Interchange of Museum Information to catalog the artworks of the principal world museums, such as the British or the Smithsonian.

By adopting the DC metadata, for each item in the database, it is possible store, among other information, the title, the author, the date of creation, the size, the format, some describing keywords, and a link to the digital counterpart. For our purposes, this can be an image (GIF or JPEG), a 3D object (VRML), a movie (MPEG, AVI, MOV), a sound (MP3, Wav, MIDI, AIFF; AU), a hypertext (HTML) or a hyperlink (URL).

Because the DC is a worldwide-accepted standard, our authoring engine can connect to eventually distributed databases too, on condition that the contained items have some digital representations in a supported format.

2.3 The Underlying Navigational Paradigm

It is widely recognized that orientation and navigation are crucial issues for an effective and pleasing interaction with virtual environments, but, in spite of that, current Web3D browsers do not offer satisfactory solutions to support these tasks. Among the major drawbacks, the paradigm of interaction in many cases is not easy to understand, often there are too many options for navigation, the default interface usually lacks tools for orientation, the visual field for desktop virtual reality is narrow and the scene representation has to be simplified due to performance limits on average personal computers [Pit01]. It is widely recognized that the guided tour paradigm allows us to resolve many of the navigational problems, since the user has to follow a preferred path in order to explore the virtual exhibition. The path is composed of a set of nodes, and the 3D
browser is responsible to move the viewpoint smoothly and in a semiautomatic way from one node to the next. To increment the effectiveness of the guided tours, preceding works led to formulate the concept of “Interaction Locus” [CeP01] to represent and characterize sets of nodes: the whole 3D environment is divided in themes, named Interaction Locus that are characterized by homogeneous morphologic features and the same interaction modalities. Each theme informs the user about its specific nature by starting a coordinated set of information streams each time the user enters inside of it. Such information streams involve several user senses, e.g. using parallel visual, auditory and hypertextual communication channels. Thus, multimodality, a peculiarity of the real world experience, is used to overcome the limits of vision in desktop virtual environments, allowing the user to gain more awareness of the 3D world structure for orientation purposes.

The navigational paradigm which is underlying the proposed system is based on the Interaction Locus concept. Such paradigm turns out to be suited for a broad range of virtual exhibitions, where a sequence of 2D/3D objects are shown to users within a specific environment and the user can receive different levels of information about each item. For example, in e-commerce, a virtual shop is constituted by a set of areas containing the goods. The user can receive an overview of each good, as well as an in-depth description of the items in which he/she is interested.

The proposed model adopts the guided tour as the main modality to access the 3D scene, but it also considers other navigational paradigms to allow users to access directly to specific features of the exhibition. Then, our navigational model proposes the following modalities to access information:

- **Guided tour**, which allows the user to navigate the virtual exhibition by following a preferred path in a semiautomatic fashion, providing a sequential access to the elements characterizing the 3D world.
- **Index**, which allows the user to navigate the virtual exhibition by identifying the elements of interest from a list.
- **VE Map**, which allows the user to navigate the virtual exhibition by identifying the elements of interest from a graphical map of the 3D scene.
- **Query**, which allows the user to access directly to any element via a search engine [CDF02].

![Figure 2. The access primitives](image)

We introduce in figure 2 some symbols representing the adopted access primitives, to visually describe the proposed navigational structure in figure 3.

All the relevant objects of the exhibitions are organized inside Interaction Locus. The main modality for navigate the virtual exhibition is then a hierarchical guided tour, that conduct the user through the set of items composing each Interaction Locus. Therefore, from a navigational point of view, entering into a specific Locus is the condition required to access information about specific objects. Moreover, as shown in the figure 3, the information about each object is structured into two different levels: at the first level the user receives basic information about its features, while at the inner level he/she gets an in-depth presentation of the item. The access to the more detailed description may be mediated by an index, because, even if in many cases there is a unique in-depth description of the item, it is possible to present to the user different information about a certain object. For example, in the cultural heritage field, it is possible to show different presentation of an artwork, given by different art experts.

Finally, note that the Query modality overrides the general rule of mediating the access to items with information about the Locus (and therefore the context) where they are placed; in this modality the visitor, interested in finding a particular information rather than in visiting the exhibition, is “teleported” in front of the desired item; after having visited the requested level, he/she may then choose to visit the rest of the exhibition or to perform another query.
2.4 The structure of the generated virtual exhibition

To realize a comfortable exhibition, the generated virtual environment is composed by a variable number of rooms, dynamically calculated basing on the amount of objects to show, like in a real museum. The 3D objects selected by the author are placed inside the rooms, by using some procedures leading to scenarios with a balanced distribution of the objects, taking also into account the real dimension of each object (coded in the database). The system has virtually no limits on the amount of objects to show, because it can easily scale increasing the number of rooms, simply linking each other. In Figure 4 it is shown a virtual exhibition generated by the system, composed by three rooms and containing some paints on the walls.
To concretize the concept of Interaction Locus, the system creates a correspondence between rooms and themes of the virtual exhibition. Each theme has its own morphologic characteristics, such as specific background audio clips, particular textures on the floor, and so on, selected within a set of predefined combinations or specified by the author. Figure 5 shows a possible arrangement of two themes, mapped onto two rooms of the virtual exhibition.

![Figure 5. A scheme of a virtual exhibition with two rooms](image)

To implement the proposed navigational paradigm, the system generates a guided tour within the virtual exhibition, which directs the user through the whole scene. Each 2D/3D object shown in the virtual world constitutes a node of the tour; for example, each theme of Figure 5 contains three items, which, once linked together, compose the guided tour. VRML clients [CorP, CosP] implements some features to support the guided tours, such as a smooth camera transition from a viewpoint to the next. Unfortunately, such transitions do not take into account eventual obstacles that are present in the trajectory between two adjacent viewpoints, passing through them. So, in order to avoid the ‘ghost effect’ of a wall-through pass, the system automatically adds some ‘dummy’ viewpoints, placed near the doors of the virtual rooms, as the one numbered 4 in Figure 5.

Moreover, the system automatically creates a list of link to all the themes and the objects composing the scene and a small map of the virtual exhibition, to allow the users to direct access to all the objects showed.

### 3. USING THE SYSTEM

The engine of our system can be profitably used in a wide range of domains, thanks to the great flexibility allowed by the adoption of the Dublin Core standard to describe the objects.

In particular we have experienced three contexts:

1. Cultural heritage, to permit institutions to easily define virtual museums;
2. E-learning, as a Learning Content Management System (LCMS), intended to support the teachers in the definition of educational virtual exhibitions;
3. E-commerce, as an authoring system to easily define the layout of virtual shops.

All these domains include a phase where an author uses the system to easily define some virtual scenes, and then a phase where the end users explore such world. In the next subsection, we will describe the graphical user interfaces (GUI), designed to support authors and end-users.

### 3.1 The interfaces for the author

The author interacts with our system, through some HTML-based interfaces, for two main tasks:

1. To specify the set of objects to show in the virtual exhibition, among those present in the database;
2. To group the set of previously selected objects, in order to define the set of Interaction Locus composing the virtual exhibition.

Figure 6(left) shows the web page that allows the author to define the exhibition. It contains 15 fields that correspond to the set of DC metadata. The author inputs the data useful to define his/her query in these fields just like a search engine, optionally using Boolean operators to define more complex queries, and then submit the form to the web server.

As result, he/she receives the web page shown in Figure 6(right), containing all the records in the database that match the submitted query. Through this page, the author can group together the objects with some inherent relations (e.g.: all the paints of a specific artist) in order to define the Interaction Locus of the virtual exhibition. Optionally, he/she can specify, for each Locus, some morphologic characteristics, such as the wall color, the audio background, and so on. If the author does not specify any grouping, the system automatically proposes some themes, basing on the input information (e.g.: Authors, Object types, creation data, keywords, etc...)

3.2 The interface for end-users

To allow the users to profitably enjoy the proposed navigational structure, we have defined a specific interface for visualizing the virtual exhibition, called VEGUI and shown in Figure 7.
The VEGUI is structured in three zones: on the top left there is the VRML canvas, showing the virtual environment. On the right, there is the hypertextual description of the shown object, while in the bottom there are the widgets enabling the navigation through the guided tour.

A start page shows to the user a link to the beginning of the guided tour, a list of links to all the Interaction Locus together with the contained objects, and a clickable map of the virtual exhibition. Once started the guided tour, the user has simply to press the button “Next” or “Previous” to move through the nodes because the 3D browser will smoothly change the viewpoint. When in front of an object, its high level description appears in the right frame, while by clicking on the object (i.e. the paint in the fig. 7), a pop-up dialog opens, showing to the user the in-deep information.

4. CONCLUSIONS

In the last years, strong efforts have been devoted towards the definition of systems that allows an easier definition and fruition of Virtual Environments. In the paper we propose an authoring system useful to easily spread knowledge over the Internet using the Virtual Reality metaphor. In fact, it enables authors unskilled of 3D technologies to create their own virtual exhibitions. The generated scenes contain a set of 3D objects selected from a database through a user-friendly, form-based GUI.

Moreover, the authoring system enables end-users to easily navigate through the generated scene, taking advantage from a specific navigational paradigm, based on an enhancement of the guided tours.

Thanks to its features, the system can be profitably used in a wide range of domains such as e-commerce, e-learning or cultural heritage.

REFERENCES


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