INTERACTION AND INFORMATION COMMUNICATION IN VIRTUAL MUSEUMS

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Abstract. This paper presents a virtual museum implementation designed in order to provide effective promotion of the represented cultural heritage objects and also to serve as a prototype of virtual educational museums. The considered virtual museum hosts 3D exhibits representing real cultural heritage artifacts and provides related to the exhibits information. User are able to navigate in it through the use of virtual characters and appropriate information communication methods are provided. The provided communication methods employ rich interaction techniques in order to engage users and enhance the learning process. An important aspect of this paper is the study of the navigational issues arising while navigating spaces of complex structure. Appropriate navigation assistance methods are deployed to reduce users disorientation incidents and a method that provides navigation recommendations is used to support their functionality. The paper also addresses issues related to the use of video game technology for cultural education purposes and provides guidelines on its effective deployment. Finally, tests including users evaluation are conducted in order to examine the effectiveness of the implemented information communication methods and the effectiveness of the provided navigation assistance.

Keywords: virtual museums, navigation methods, information presentation

1. Introduction
Three dimensional (3D) virtual environments, also called 3D virtual worlds, increasingly become a suitable solution for modern applications in the area of visual representation. Having many characteristics such as intuitiveness, easy of use, interactivity and immediacy, virtual environments are also applicable in promotion and preservation of cultural heritage [1]. Museums soon realized the potential and benefits of virtual environments, aiming to the development of educational content and services for their visitors. So they created their digital version, Virtual Museums, which are websites or applications that simulate a 3D world, in which the exhibits have been developed in virtual way. A virtual museum allows users...
tour into the virtual world, while interacting with exhibits and getting informed with related information about them. Virtual Museums aim to explore the benefits of using virtual reality in the premises of museums, in order to help both researchers and general public learn through an alternative, more entertaining way (Edutainment), while preserving and bringing to prominence cultural heritage exhibits. However, Virtual Museums indicate a lack of usability, which is usually due to non-comprehensible or too complicated tour techniques which are being used. In this paper two important aspects of virtual tours are studied: (i) navigation assistance; and (ii) information communication. The aforementioned aspects are considered important in order to enhance usability and information intake. A demonstrative virtual museum integrating navigation assistance and information communication methods is developed in order to evaluate their effectiveness.

2. Information Communication Methods in Virtual Museums

Information communication is considered to be an important aspect of both physical and virtual museums [2, 3]. Museums serve as information communication media by exhibiting their artifacts and by deploying appropriate information communication methods [4]. Multimedia content, e.g., video, images, audio, etc., is frequently used by virtual museums for information communication [5].

2.1. Video & Images

In this paper, videos and images, are studied as a single information communication method due to their visual form and the absence of interactivity. Videos are audiovisual means, which if they are prepared and processed in a right way, they can combine usefully many different types of information such as text, sound, stable or moving images, graphics, etc.

In addition, videos are able to present realistic 3D virtual exhibits, no matter their real location, size or age, giving the chance to visitors for learning about them through their virtual tour [6]. In this case, some of the exhibits are objects, buildings and places, which cannot be shown efficiently and completely during a virtual tour, due to their dimensions and the limited time that visitors provide for their tour. Using audiovisual means for providing information in virtual worlds, especially videos, is an ideal option for cases in which a lot of data and information have to be presented.

Additionally, visitors with audio-visual experiences during their tour in museums, were able to memorize, remember and analyze information and details about the exhibition they watched [7].

To summarize, using videos as a main information communication method in a virtual environment for the purpose of promoting and educate has many benefits which are concisely mentioned below: (i) they constitute direct and brief type of information, while they totally cover the presentation of the exhibit in a short time period; (ii) while creating them, the author has the opportunity to express personal feelings, opinions, viewpoints and bring out messages to the visitors; (iii) they can present every kind of data or information; (iv) they offer directness, as they visualize data information for the visitor; (v) they are able to create a special kind of atmosphere into the virtual world; (vi) they are able to provide users with realistic information about what they present; and (vii) they already stand as a known and friendly way of informing for every kind of visitor. Besides its advantages video, in its traditional form, lacks of interactivity.

Video projection in the presented virtual museum is described below. Into the virtual museum, videos play essential role for information communication and exhibit presentation. Videos are being projected on the surface of the walls, covering a fully presentation of virtual 3D exhibits, accompanied by audio. An interaction feature has been also integrated, as every video starts playing when visitors approach its surface and it pauses when they walk away from
it. More interaction options are given to users, as they are able to start or stop playing the videos by giving keyboard entries.

2.2. Text
In addition to multimedia, text is probably the most widely used information communication method. Text contains information and details about presented exhibits but it cannot represent an exhibit by itself. However, it can be combined easily and efficiently with every other method existed, as it has the ability to provide information that cannot be displayed in different way. The main reason for choosing text to be combined with other techniques is because of the secondary role that text plays next to exhibits. In physical museums, text is used to accompany exhibits, providing additional information about them. Important details such as locations, age, dates, names, historical facts and more, can be easily provided. Moreover, information provided through text is direct and difficult to misunderstand by visitors.

Text as an information communication method provides the following advantages: (i) it is direct and contains only the needed information; (ii) it can be understood easily by everyone; (iii) it can be used in order to provide knowledge to every social kind of people, no matter their previous education level, age, experience, etc.; (iv) it is able to transmit author’s personal messages, opinions, viewpoints; (v) it is hardly misinterpreted when is written, organized and presented in a right way.

Text integration in the presented virtual museums is described below. Text is also used into the museum for guiding visitors and provide them with additional information about the exhibits they are watching. Projected text is being read from text files, in order to be easily modified and organized. Text is integrated in both videos and 3D holograms, and it can be shown and hide when users want to, by giving keyboard entries. Users are also able to move on the next lines of the text while reading, by keyboard entries, too. Depending users position into the virtual environment, text is projected to them in order to guide them about their options, or provide information relatively with the exhibit they observe.

2.3. Audio

Audio is an important information communication method in both physical and virtual museums [8]. Audio data is usually used for providing additional information about virtual exhibits in virtual reality and in most cases accompany or replace text. As it is used for providing details about exhibits, audio usually has the form of narration. Narration and text have many similarities, as in most cases a narration can be printed in text. A well-organized narration during a virtual tour is able to transmit author’s feelings, opinions and viewpoints about an exhibit in the museum. Moreover, it is easily understanding, direct and hard to misinterpreted. Narration is very helpful as a means of information communication used by people with vision impairment or a lower education level, which make it difficult or impossible for them to read.

2.4. 3D Holograms

3D holograms [9] is proposed in this paper as a method of information communication in virtual museums. 3D holograms are used to represent three-dimensional digital exhibits in a virtual environment. This kind of method has rose steeply during the last years, promising crucial changes in near future, at the field of information providing for both virtual and real-life environments. 3D holograms can be used to represent real world objects that have been shrinked in order to fit in place. 3D holograms can be passive as traditional museum exhibits or interactive. Holography as an Information Communication method for virtual exhibits has many benefits in contrast with other related techniques, while the same time is the best way to present the potential of 3d graphics in either virtual or real environments. Interaction features are incorporated enabling holograms to start rotating when visitors get
closer to them, and stop when they move away. Moreover, users’ keyboard entries are also acceptable for start and stop rotating holograms when they wish to.

2.5. Cave Automatic Virtual Environment

CAVE (Cave Automatic Virtual Environment) [10] is an interactive simulator of virtual environments which is used in real life world. In this paper virtual CAVE installations are proposed as a information communication method in virtual museums. CAVE is a room with the shape of a cube. In some cases, one wall of the block is missing, as this side is used for entrance. Outside the room there are projectors which synchronously light up every wall, creating an experience of a complete virtual world for the observer. Visitor uses 3D glasses which provide 3D-depth image. Surround speakers are also being used for achieving realistic sound effects. The system allows user to move and interact into the virtual world by using the control system in three ways: (i) Motion Joystick; (ii) Touch Pointer; (iii) Wireless Position Sensor Polhemus. CAVEs in virtual environments are quite different in the way they work. The concept of the projected room remains, but there is no need for special equipment such as projectors, 3D glasses etc. The visitor enters the room, into which a different virtual environment can be projected. In this way, many different topics with the form of virtual environments can be integrated into a single virtual tour. System controls can be managed by using simple peripherals, like keyboard or mouse, but also specialized technologies can be used, such as VR glasses, motion trackers, etc, for a better experience. While into the room, a whole virtual world is projected in visitors eyes, filled with available exhibits and related information. However, it remains a personal choice for the user about how he will move in the virtual world and with which exhibits is going to interact. CAVE is an alternative way of information communication as it uses interaction as its main feature in combination with the selected theme which is projected. In this way, it sets users free to tour themselves in the virtual world and interact into it, while a specific topic with a main idea is simulated into the room. This is why CAVE is currently being used in a variety of fields, such as education in universities, or just for entertainment by simulating games.

Koutsoumpidis et al. [11] propose an interesting method for cultural content communication as they use 3D avatars of historical personalities for information communication combining both visual and auditory stimuli.

3. Navigation and Interaction in Virtual Museums

Navigation is the process or activity of accurately ascertaining one’s position and planning and following a route. During the last years, it has become an essential part of all Virtual Environments. While VR space grows, navigation becomes even more challenging, as its main goal is to be as simple as possible, and the same time preserving the elements of exploration and discovery [12]. This is what makes the technique which is used in VEs efficient. Due to its large scale and the number of included points of interest, users navigation problems [13] show up.

Effective users navigation is prerequisite as the virtual environment aims: (i) To cover extended areas; (ii) Having many points of interest; (iii) To provide users spatial knowledge useful in virtual and real visits too; (iv) Avoiding users disorientation that would cause frustration; (v) Recommend paths to follow. For an effective navigation, it is essential for users to be able to orient themselves in the virtual environment, observe navigation marks and obtain knowledge about the space. However, there are four different factors that constitute navigation and affect its efficiency in a virtual world. (i) Way finding; (ii) Travel; (iii) Users; (iv) Virtual Environment itself [14].

Komianos et al. [15] present the most common navigation techniques which are used into virtual environments and listed here (i) 2D maps; (ii) Location pointing using arrows; (iii) Oral
directions; (iv) Textual descriptions; (v) Orally-assisted destination recognition; (v) Destination recognition supported by appropriate illumination; (vi) 3D Tour Guide.

3.1. Static Indicative Arrows in Virtual Museums
The use of static arrows is an ideal option for navigating in not too complex environments such as the virtual museum, due to their low computing cost, in combination with the level of assistance they provide users with. Into the virtual museum, static arrows are being projected onto the floor, depending on the users space position. Arrows inform visitors in which direction they should move in order to visit every available exhibit. When the virtual tour starts, arrows are initially invisible, and they can be projected or hide again by visitors keyboard entry. Arrows created based on two essential characteristics, in order to avoid information loss or alteration. According to [15], arrows should be (i) evident and (ii) modest.

3.2. Interaction Borders in Virtual Museums
Interaction borders are proposed in this paper. Interaction borders are borders placed onto the floor of the building, marking the surface into which users are able to interact with the exhibits, as well which specific exhibit they involve. Those borders are projected depending visitor’s position into the building, and can be shown or hide when users need to, after a keyboard entry.

3.3. Experimental Design & Main Idea
In order to evaluate the utility and need for navigation assistance in virtual environments, a user participation experiment has been designed. The navigation assistance method which was selected to be evaluated is static lines - which are similar to static arrows - places onto the floor of a building. More specifically, the experiment tries to simulate cases of virtual environments, in which users have to navigate under conditions of complicated space design, into environments with numerous possible points of interest. The evaluation is estimated relative to the time users need to navigate themselves into the virtual space. For this purpose, a large space virtual environment has been created, with sixteen similar rooms into it. The building has four entries in random positions, to its outer sides of walls. As for the entries to each room, they are also placed in random way. On the floor of the building, navigation lines has been designed, starting from each outer entry and finishing to each room. A teapot has also been placed into one of the rooms, which represents a possible exhibit. Moreover, each inner room represents a possible point of interest.

3.4. Procedure & Tasks
The experiment is conducted to random users who can participate as many times as they wish to. When the procedure begins, each user controls a virtual character who starts from one of the four outer building entries. The starting point is selected randomly. Into the building, one of the rooms, which is chosen also in random way, contains the teapot, while the rest of the rooms are empty. The users have to navigate themselves into the building with only one goal, to find the teapot among the rooms. In some cases, users are provided with assistance through the navigation lines on the floor of the building, but there are also instances, in which users have to navigate themselves alone and find the teapot without any help. During the procedure is in progress, an overseer observes the experiment and writes down the times users need to move in the virtual space until they find the requested teapot. The main concept of the experiment is to compare the recorded times, between cases with and without the navigation lines, in order to examine their utility, and the efficiency of navigation assistance.
3.5. Results Discussion
In our first attempt for collecting data, 11 random users participated in the experiment, with a total amount of 32 tries. Although time results during the procedure were interesting, the final results after analyzing data were more than informative. To be more specific, as the table below shows, the total average time users needed to find the teapot in cases without navigation assistance was 22.72 seconds, while in cases with navigation assistance they needed only 9.51 seconds.

Results prove that navigation assistance of static lines used in space complicated environments are able to reduce tour time up to about 58.14%. Of course, as it is expected, more data collected are able to lead on more representative results. Nevertheless, numbers still remain informative about the utility and efficiency of this specific navigation assistance method.

![Image](image1.png)

**Figure 1.** Video projection and virtual CAVE installation in virtual museum. The video is accompanied by text. The virtual CAVE installation uses static arrows and interaction borders in order to enhance its usability.

![Image](image2.png)

**Figure 2.** Holograms and interaction borders.

4. Conclusions
In this paper a set of methods providing information communication and navigation assistance in virtual museums is presented. Regarding the information communication, the proposed methods are mostly based on conventional methods which are appropriately integrated in virtual museums. Early tests show that video projection accompanied by narration and text descriptions have positive effect on users experience. According to users virtual CAVE is interesting and the authors consider that when equipped with appropriate scenarios can be further improved. Holograms are observed to attract users in early tests and increase their engagement. The provided navigation assistance
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