

Preparation and presentation of cultural content in virtual environment

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ABSTRACT

The paper presents a web-based application for preparation and presentation of various two- and three-dimensional cultural showpieces in a virtual environment. Specific task modules built on a common database provide tools for designing spatial models of a real or a fully virtual gallery, exhibit management, arrangement of exhibits within the virtual space, and final web presentation using standard VRML browser and Java applet. The whole application serves for different kinds of users – gallery owners, artists, and visitors. A use of virtual reality paradigms for image presentation purposes is discussed here, too.

Keywords: virtual gallery, cultural heritage, Internet, VRML, Java, web-based presentation

1. INTRODUCTION

Images are considered as an integral part of web-presentations for many years. Advanced technologies like virtual reality (VR) have brought new paradigms for presentation and studying images – a three-dimensional (3D) space. Although the nature of most images is definitely two-dimensional, real images (printed, painted) are to be finally placed into a spatial environment. Virtual reality thus helps to check various image properties like positions and lighting before their exhibition in a real world. This approach is especially convenient for presentation of cultural objects like paintings and sculptures. For this purpose an application named Interactive Virtual Gallery has been developed. A structure and a functionality of the first version of this application are described here.

The paper is organized as follows. Section 2 discusses advantages and disadvantages of utilization of virtual reality principles for presenting cultural objects. Existing approaches are classified. Questions concerning methods for preparation, processing, and presentation of virtual models based on artistic objects from the real world are introduced in Section 3. A design of the Interactive Virtual Gallery application is described in Section 4. Practical observations are listed in Section 5. Section 6 concludes the paper.

2. WEB-BASED PRESENTATION OF CULTURAL HERITAGE

Currently almost all museums and big galleries over the world offer certain presentations of cultural objects on their web pages. The aim is to attract Internet visitors for a real visit, to show the best artworks, to inform about new collections and exhibits. When concentrating on images (2D exhibits) only, a big range of web presentations exists starting from a list of image preview on one HTML page, going through complex multi-frame presentations including additional textual information, historical facts and even audio annotations, and ending with 3D virtual tours through a gallery/museum space. The later case is discussed in this chapter.

The term “virtual gallery” covers many different approaches for web presentation of various collections. When searching the web using Google engine, about 1.200.000 references to that topic have been reported. We have classified them into the following four categories:

- *2D presentation*
- *Panoramic views*
- *Static 3D gallery*
- *Authoring 3D gallery*

The first kind of virtual galleries is the most frequent. *Image collections* are organized into thematic groups. A typical approach includes a small preview with a hyperlink to a higher resolution image. Light conditions in a real gallery are

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not considered – images are presented in optimal lighting. Possible relationships among images are constituted on logical base rather than the spatial one. A creation of such a virtual gallery does not require any special software tools – commonly used HTML pages with GIF/JPEG images can be even produced automatically with the help of a database and any scripting language.

Panoramic scenes represent a bridge between 2D and 3D presentation. Typically based on the QuickTime VR (QTVR) technology⁹, panoramic images allow users to get feeling of a real gallery visitor in a 3D space. A user is placed into a center of cylindrical panoramic background that holds a seamless sequence of photographs taken from a static position inside a real gallery. A visitor can turn left or right as well as zoom in/out the panorama. Each panorama has to be prepared in special conditions – a camera position has to be carefully selected allowing viewing of many exhibits, a gallery has to be empty (without visitors and other view obstacles), light conditions should be tuned with respect to the camera position. Although final panoramas are of a good quality (multi-resolution and streaming through the web are significant features of the QTVR technology), a high quality of presented images cannot be achieved in principle due to a perspective distortion and a big distance from a camera. A method is suitable for presentation of unchangeable environment. Any small change in a gallery requires a new creation of the whole panorama. That is why stable institutions like Louvre gallery⁷ in Paris, France, prefer it. A panoramic image can contain sensitive areas with hyperlinks to another panoramas or HTML pages. Unfortunately this useful feature is not commonly used, perhaps because of inexperienced users that do not expect/utilize it.

Fully *3D galleries* take advantage of virtual reality paradigms – free navigation in 3D space, interactions, and animations computed in a real-time. Thanks to a rapid development of 3D graphics hardware during last years, currently almost all new PCs are able to smoothly render medium complex 3D environments, i.e. scenes containing thousands of polygons and hundreds of kilobytes of images/textures. The most common descriptive language for 3D graphics on the web is the Virtual Reality Modeling Language (VRML), published as an International Standard⁴ and further developed by Web 3D Consortium¹⁰. While VRML viewers are publicly available, authoring tools (editors) are to be paid. This fact has a main negative impact on a wide presence of 3D galleries on the web. The bottleneck is neither the network capacity nor rendering performance on client side, but the ability to create and change a 3D model of a gallery and its content.

Most 3D galleries on the web are *static*. They allow navigation in 3D space either freely or by selecting predefined 3D viewpoints, but the content cannot be changed. If the exhibition has to be changed a new VRML scene has to be created either by general modeling programs like 3D Studio Max or specialized VRML editors. All such programs are typically composed as single user tools – collaborative work, e.g. between gallery owner and an artists/exhibitor, is not supported. *Web-based* modeling and authoring programs are still rare. A few examples include Outline3D⁸ (general tool offering to design several rooms and to equip them with furniture and other objects from predefined set of models), and Virtual Interactive Art Gallery² from GEIRA project (set of tools that allows to interactively place paintings on statically defined walls, and set lightings appropriately). While the first example does not contain features specific to gallery presentations the second one has been designed with respect to certain gallery requirements. Our application is similar to the second example and extends it towards interactive and easy-to-use modeling of a gallery.

3. USE OF VIRTUAL REALITY PARADIGMS

A use of virtual reality in the cultural area is often considered as an issue arousing different and even opposite attitudes. The virtual reality requires new skills of users – a 3D space is presented on a two-dimensional screen, but still allows navigation in space and interaction with spatial objects. Users have to get familiar with spatial navigation and manipulation techniques. Well-known and simple paradigm “click and see” used in web browsing is changed to “enter and search” method in 3D virtual space. This is considered as an obstacle for classically educated and inexperienced users, while on the other hand it is quite natural way for young people (formerly computer game players), artists working with new media, etc.

Another set of questions deals with a need to use a 3D space for presentation of 2D objects that paintings definitely are. Indeed the best utilization of a 2D computer screen is in displaying an original image without any perspective distortion, scaling down, and lighting effects that are naturally present in virtual space. By our best opinion, the virtual reality cannot compete with traditional 2D ways of image presentation, but it should enrich them and cooperate with them.

Taking our many years experience with low-end virtual reality (i.e. VRML) into account, we declare the following application areas where web-based VR can successfully serve for cultural heritage presentation and preparation:

a. *Interactive design of exhibitions*

Since real presentation environment is always three-dimensional, VR can be used as a modeling environment for preparation of expositions. We can distinguish two different models – a gallery model and an exhibition model. Since the gallery itself does not change too often it can be considered mostly as a static model. The exhibition model is a subject of changes – paintings are hanged on walls or moveable panels, 3D artworks are placed on placeholders located on the gallery ground. Gallery curators and artists preparing a new exhibition within already existing rooms/buildings can take advantage of interactive work in virtual reality. They can set proper spatial arrangement of all showpieces in advance and then export a final list of geometrical information (position, measures, etc.) for real setup of the exhibition. Such tasks can be achieved using modeling programs from CAD/CAAD area, but it is advantageous to work within VR environment from the very beginning due to the consistency and interchange of data. Our application introduced in this paper meets most of these requirements.

b. *Lighting setup*

A proper lighting is one of key issues when presenting cultural objects to the public. Computer simulated spatial scenes allow studying a visual look of exhibits during various daylight conditions and different inner light settings. Again, a computer simulation can precede a real installation and shorten the time for the overall preparation of an exhibition.

c. *3D guided tours*

While the previous two applications of VR were targeted to specialists preparing a real exhibition, a virtual gallery can be easily published on the web to attract and inform Internet users searching for a cultural content. Navigation in 3D space should not be an obstacle but an advantage. A system for gallery/exhibition design should prepare a rich set of viewpoints that are offered to web visitors as a guided tour through a gallery space. Searching for specific artwork should lead to an automatic navigation to a viewpoint with the best possible view to that exhibit. A user can choose even several artworks – a program then prepares optimal (the shortest) path going around them and creates a 2D map or another schematic plan to be printed out and taken with a user to a real visit. Internet users could even meet each other in a virtual environment, share their interests, discuss their impressions, etc. One such attempt in the area of Central Europe is being developed under the name e-Agora¹. Another interesting method extremely useful in a phase of exhibition preparation is a simulation of crowds of visitors. A web application can store all visitors' movements when they navigate in a gallery model. Such log files can be continuously evaluated with the aim to find possible bottlenecks when crowds of people visit the gallery. Crowds and their behavior can be also simulated in advance (Tecchia et al.⁶). Such an evaluation can help to increase a security of an exhibition, e.g. by automatic finding of watchman positions.

To characterize the above applications from the point of practical implementation, the first and the last item is quite straightforward and can be achieved in principle without any special effort with existing technologies like VRML and Java. The second kind of application (lighting setup) represents a big issue that cannot be solved easily and even in a real-time.

Lighting setup problem consists of several minor issues. First, light sources used for fast computation in Computer Graphics (and thus in VR, too) are point lights only. Area light sources (like windows or light panels) have to be processed by a special method known as *radiosity*. This method is able to evaluate shadows and multiple diffuse reflections, but it is computationally demanding. Next issue deals with light reflections on paintings. In contrary to standard image processing, where images are considered as arrays of color pixels described by color primaries only, lighting models in 3D space require additional information per pixel. Well known *Phong* lighting model (often implemented in graphics cards) requires information on diffuse and specular reflection properties per each pixel. Having such information, one can perfectly check the look of a specific painting as a combination of visitor's position, position of a painting, type of paints the image is made from, and light conditions in a room. Unfortunately, such data are not usually available. To get specular reflection characteristics of an image, an adjusted setup consisting at least of two independent point light sources should be used when acquiring/scanning the original painting. Last issues belong to a final rendering of paintings in 3D. Although shadows can be pre-computed in advance and stored as texture/shadow maps for walls and other large objects, reflections on paintings have to be rendered in a real-time. Here we meet with

practical limitations in graphics engines/cards. Most of them are able to use maximum of 8 lights simultaneously. Advanced graphics boards manage up to 16 or 32 lights, but this number is still not enough for large galleries and other exhibition spaces. The VR system must either dynamically switch lights on/off when a visitor walks through the virtual environment or simply to limit the overall number of light sources. Another limitation in VR browsers is the fact, that images are often considered as textures, i.e. arrays of color pixels without reflection properties. Full lighting model is evaluated for geometrical surfaces but not for textures. This is the case of VRML. We hope in better texture processing in a near future since graphics hardware is already able to compute it using so called multi-texturing that includes shadows, reflections and colors.

4. INTERACTIVE VIRTUAL GALLERY

The application Interactive Virtual Gallery has been built with respect to the following principles: ease of use for users inexperienced in 3D computer design, utilization of advanced features of virtual reality (navigation, perspective projection, interaction); gallery presentation on the web enriched by useful functions (e.g. automatic 3D navigation to selected exhibit). The aim was to develop a complex tool for cultural heritage presentation and administration. The complexity means not only a number of functions available, but also a possibility to open a virtual gallery to different users with different roles. A gallery owner/keeper can create a model of a gallery space and dynamically change its setup (e.g. positions of moveable panels/stands); an artist can prepare his/her own exhibition using principles of virtual reality and check it before real (possibly large and heavy) exhibits are placed to their final positions; visitors can enjoy a walk-through the virtual gallery accessible via Internet and plan the visit of a real (possibly spacious) gallery in advance. The three-dimensional presentation is based on VRML.

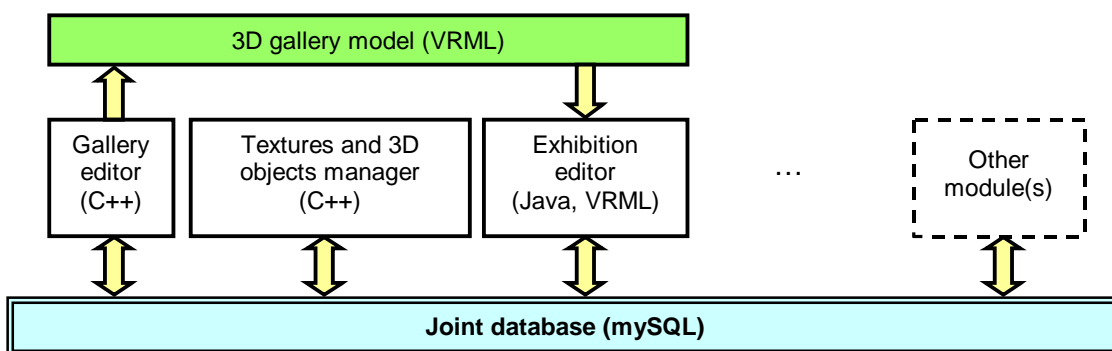


Figure 1: Modular structure of the application built upon the common database is suitable for independent development of further parts as well as updates/improvement of existing modules.

Taking into a consideration that every software package is a subject of changes we have chosen a modular structure as shown in Fig. 1. The main and common part is a database, in our case implemented by publicly available MySQL program. The database holds information on geometrical properties of a gallery space, exhibits and other parts of a virtual model. Thanks to a Java interface a database is also accessible via web. It allows several users to work concurrently, although locking mechanism has not been implemented yet. The main advantage of using database lies in a possibility to build a set of independent modules on a top of the database. Every module serves for different purpose but shares data with other parts of the application. Three implemented and cooperatively running modules are described in the following sections.

4.1 Gallery Editor

The module represents a simple 2D editor (with 3D preview) for a model of a gallery space. We have chosen a planar view (ground plan) for the sake of simplicity and lucidity (Fig. 2). Although the primary method for designing a gallery is to draw it interactively by a mouse, users can also work with help of a snapping grid, distances, and angles like in real CAD/CAAD systems. A polygonal ground and an invisible ceiling have an elevation specified. A gallery consists of several rooms with different elevations and heights connected by doors, corridors, and stairs. The Gallery Editor works with just a few basic geometrical elements – grounds, ceilings, and walls. Other 3D objects are to be included into a gallery from a set of arbitrary VRML models. This strategy leads to a universal utilization of VRML objects representing a library specific to a certain gallery – models of doors, windows, furniture etc. The Editor imports those

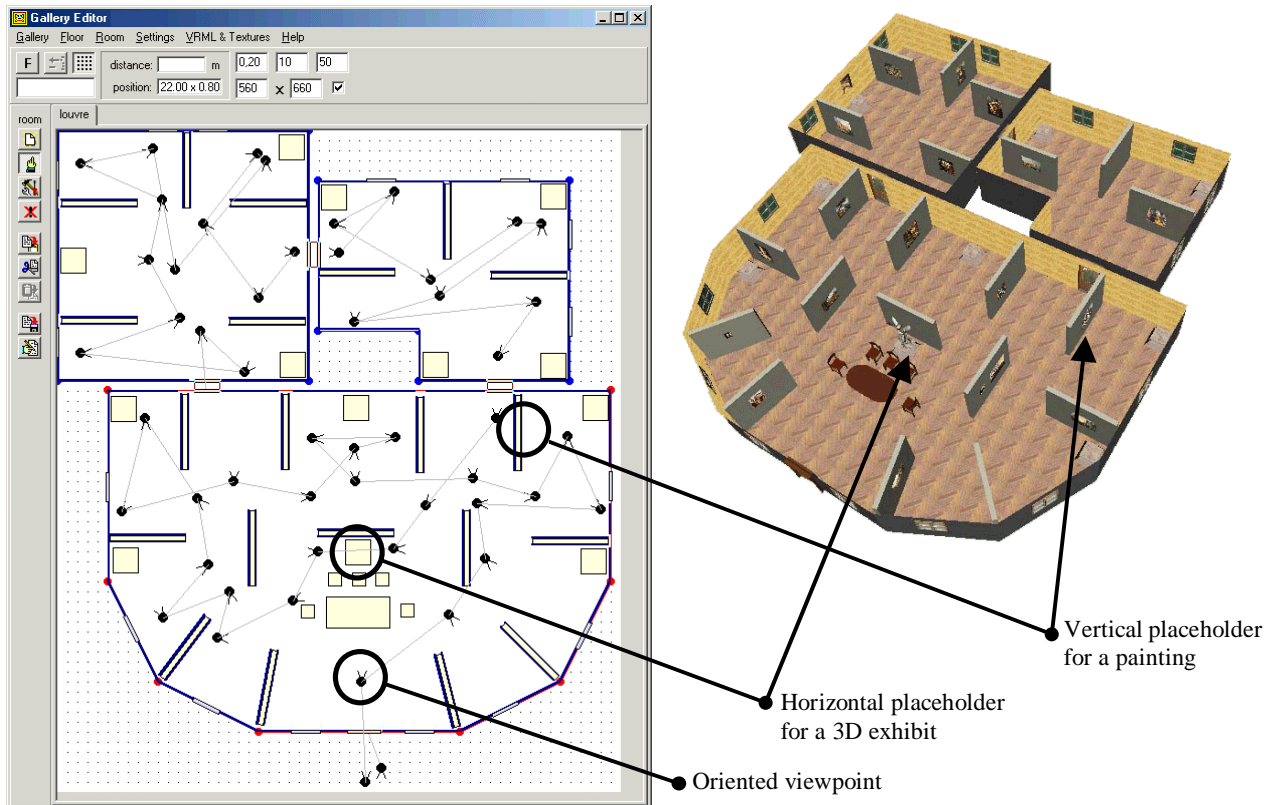


Figure 2: The Gallery Editor (left) provides tools for a design of a gallery in 2D space. It also allows placing additional information later used for the navigation in virtual reality – see paths defined by an ordered sequence of viewpoints. Placeholders for artworks are used in the next module – Exhibition Editor (see snapshot on the right).

VRML objects and displays corresponding bounding boxes in a ground plan of a gallery. When inserting doors and windows (possibly interactive objects because of their VRML nature), the Editor makes appropriate holes in existing walls. When a model of a gallery is created it does not contain any exhibits, but placeholders for them instead. Preparation of exhibits is a task for another module – the Exhibition Editor. Let us highlight the fact that vertical placeholders (for paintings) and horizontal ones (for 3D exhibits) are managed like any other VRML object. They represent a basic part of a VRML gallery object library.

A list of the Gallery Editor functions includes setting of colors/textures for gallery parts, copy and paste objects and even whole rooms, etc. One of the most advanced features is a function for connecting rooms. When a joint door is placed between two rooms, the room relationship is saved internally. If one room is later moved to a different position the Editor automatically creates a corridor between those rooms. When connecting rooms with different elevations, appropriately adjusted stairs are offered to a user. Another useful function for VR navigation is a viewpoint setting. Arbitrary number of 3D viewpoints (together with their view angle and field of view) can be arranged into a virtual tour through a gallery. The whole gallery can be exported into a VRML file anytime for a preview purposes as shown in scheme in Figure 1.

Since the Gallery Editor is typically used by a specific subset of users (gallery owners, gallery keepers) and gallery models are not considered as frequently changed entities, the Gallery Editor has not been designed as a web-application. It is a standalone application written in C++ communicating with a locally installed database. To allow more than one user to design/change parts of a gallery, an interchange format “gal” has been designed. The format holds a content of specific gallery together with all relevant VRML objects, textures and other data. Users can work with Gallery Editors on their local computers and export/import their data using “gal” format. The Editor informs about possible inconsistencies when loading rooms into already existing gallery space. The format also serves for archive purposes.

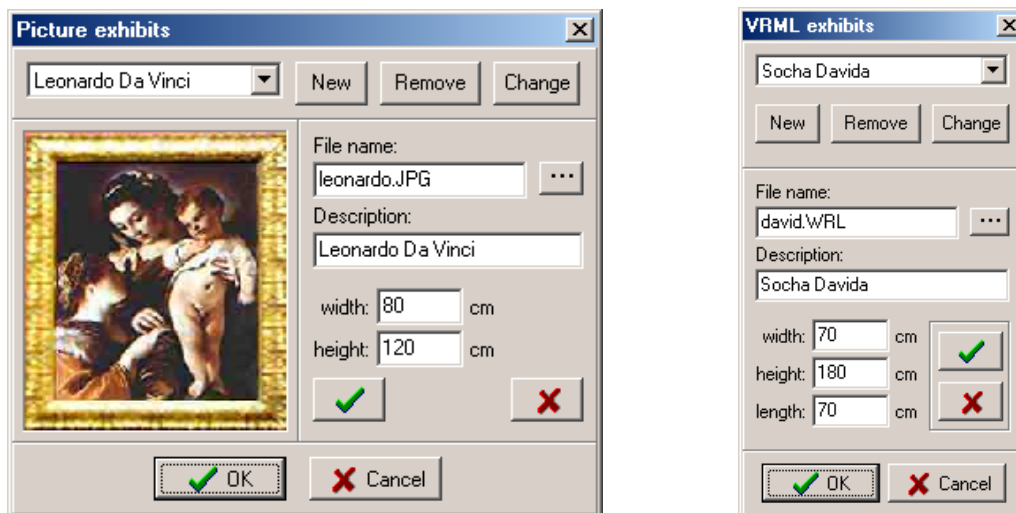


Figure 3: Paintings and 3D objects are included into a database using two simple modules. The first one manages paintings (left), the second cares about objects described in VRML (right). Both allow adding a short annotation useful for searching the database.

4.2 Exhibit Manager

A set of images (paintings) that are to be exhibited is added to a database using simple manager module. A user has to specify real dimensions of a painting and optionally textual annotation (Fig. 3). Current version accepts image file formats that are coupled with VRML specification only, i.e. JPEG, PNG, and GIF. Due to the later use in VR, a size of such images should not be bigger than 512 x 512 pixel. This limits the visual quality a lot. Here the multi-resolution approach would be highly appreciated – we are going to accept images of any size, to process them and store in several resolutions. The image size influences also a time required for image transfer through the web. When presenting a gallery with tens or even hundreds of paintings in a 3D virtual environment, low quality images are transferred from a server to client browsers at the beginning, since the shortest possible time is required. High quality images can be loaded later as visitors search the gallery space. This can be done automatically with respect to a current visitor's position or interactively when a user individually selects specific image. The later method is common in HTML-based image presentations (click and wait for better image).

The second tool used in Exhibit Manager serves for including 3D exhibits into a database. A multi-resolution approach takes place here as well. Since spatial artworks have to be described in VRML, we naturally make use of the LOD (Level Of Detail) principle in VRML language. It is based on creation of several discrete representations/models for one object. A rendering subsystem automatically selects appropriate model for presentation according to current distance between a visitor and the object. The number of LODs per one 3D exhibit is not limited, but in practice three or four representations (best, medium, simple, none) are sufficient. A balance between visual quality and amount of descriptive data is important here as well. Discrete levels of detail have to be prepared in advance, outside the Interactive Virtual Gallery application. Current version of VRML does not work with streamed multi-resolution triangle meshes (like introduced e.g. by Hoppe³) that are more memory efficient and visually smoother than switched discrete representations. Hopefully next version of VRML known as X3D will figure out this issue.

4.3 Exhibition/Presentation Editor

This part of the application is targeted to the web. It allows opening a web page on a client computer, downloading a virtual gallery model described in VRML, connecting to a database on a server, and manipulating with exhibits (Fig. 4). The last function has been designed as password protected. It represents the only difference between an artist preparing final exposition and a visitor searching for information in a specific gallery. The artist/exhibitor can add paintings to vertical placeholders and 3D showpieces to horizontal ones. Exhibits are selected from a database and interactively positioned in 3D virtual environment. Placeholders play a role of "stick" area – they hold the exhibit with limited degrees of freedom (translation within bounding rectangle, 3D object rotation around vertical axis, etc.). Exhibits are borrowed from a database like from a real archive – when placed in a virtual gallery their visual



Figure 4: The Exhibition Editor contains VRML viewer and Java applet working together within one HTML page. The applet consists of editing menu, paintings selection area and spatial exhibits selection area.

representation disappears from the database list, when deleted from 3D virtual space they are “moved” back to the database.

Both exhibitors and web visitors can navigate in 3D environment either by selecting predefined viewpoints or freely using a mouse or other input pointing device. Instead of developing own VRML browser/viewer we have taken advantage of existing publicly available browsers. Currently the most stable and ISO standard conforming browser seems to be Cortona from Parallel Graphics. It implements the EAI standard interface⁵ between VRML world and cooperating Java applet quite reliably, thus the messy combination of Internet browser, VRML browser, Java Virtual Machine interpreter, and Java applet made typically by various developers works relatively well. It should be noted that the whole application runs on MS Windows platform only.

The web application offers a useful function – looking for already installed exhibit either by its name/annotation or visually from a list of small previews (in case of paintings). A visitor is then automatically navigated in 3D space to a new dynamically generated viewpoint that is 1 m in front of the selected exhibit. This function represents an important step for overcoming a gap between virtual reality navigation principle and traditional way of working with computer screen.

5. EXPERIMENTS AND OBSERVATIONS

The application has been created as university project without direct connection to real cultural bodies. Nevertheless we have made discussions with several experts from Czech cultural area during the design, implementation, and evaluation.

They have found the Gallery Editor highly useful and easy to use comparing with general modeling packages like AutoCAD. Since almost no gallery has its own digital plans available, the import of external CAD data has not been requested, however the next version of the application should definitely care about it.

The web-based Exhibition Editor has been also accepted positively, although a few recommendations have been made. An “intelligent” displacement of paintings would be appreciated. It includes automatic positioning to specified height or placing images into a row with constant spacing (offset) among them. Such functions can be implemented without problems in next version.

Finally we have found performance limitations when rendering large virtual scenes that consist of many rooms with big number of exhibits. Not only a user has to wait too long for downloading a whole gallery from a server but also a speed of rendering falls down markedly. To solve this problem we are going to adopt a principle of dynamic downloading gallery rooms on a fly as introduced in Zara et al¹¹. A client computer will hold a data describing currently examined room plus its neighbors only. New rooms will be then downloaded as user passes through a door to the next room.

6. CONCLUSION

We have discussed a use of virtual reality paradigms for the preparation and presentation of cultural objects, namely paintings. Several application areas have been identified and main implementation problems introduced. The application Interactive Virtual Gallery has been described. While the general application architecture has proved to be stable and well designed, couple of advanced features is still under the development and discussion. The most challenging task is the lighting setup in a virtual environment that should carefully follow light conditions from the real world. Another task is to work with large amount of data and manage them dynamically thus achieving high frame rate on a client side. The application represents a first step from simple virtual scenes to a serious and practical work utilizing new paradigms and full richness of real-time 3D interactive virtual environments targeted to the web.

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