Code ar2084

Generative VR and the Representation of Traditional Architectural Elements

Abstract:

Generative VR may be described as a model that recreates a concrete or an abstract entity, captures its quantitative (and also qualitative) parameters, allows the study of its structure and behavior, incorporates the higher degree of interpretation, and still leaves space for a subjective way of "seeing" it.

The aim of this paper is not "realism" alone for the sake of imitation, but to contribute to understand virtual reality –regarding traditional architectural elements- as implying the use of three dimensional computer graphics in a system that is [at a minimum] real-time, immersive, and interactive. Cultural Virtual Reality (CVR) is the use of VR systems especially for the presentation of the world's cultural heritage sites. To understand reality and all of its complexity, we must build artificial objects and dynamically act out roles with them. That means transforming "virtual" into "augmented" reality. Augmented reality has been defined as the simulation acquisition of supplemental virtual data about the real world while navigating around a physical reality. For information pertaining to complicated 3D objects, augmented reality is an effective means for utilizing and exploiting the potential of computer based-information and databases. In this sense a virtual world is something more than a visually "realistic" geometric models, it is a dynamic model that changes in position, size, material properties, lighting and viewing specifications. Future advancement of virtual reality technique should not be restricted to "presentation" techniques, but to explanatory tools.

Conference Topic: Virtual Environments,

Keywords: Virtual Reality, Virtual Reconstruction, Knowledge Representations, Islamic Architecture.

1. INTRODUCTION

The term **virtual reality** (VR) describes acceptable substitutes for real objects or environments. In cultural heritage virtual reality finds a wide area of applications as a way of visualizing and describing sites of archeological and historical interest that may no longer exist or that are damaged. Along with new ways of sharing information such as internet and multimedia, virtual reality makes a large number of people more familiar with cultural heritage.

Virtual reality's use in cultural heritage can be summarized to the following sectors:

- As a tool the scientists
  - Describe the data
  - Visualize the proposed reconstruction
  - Work with the data and the model describing a site more efficiently that if we had the model in paper
  - Record and store the data in a visual figure which is more easy to understand and translate since humans conceptualize visual data much more readily and proficiently than mathematical data

    - Work on the sites without interfering with the physical environment
- As a way to present cultural heritage
    - Visualize cultural sites in a more conceptual and interesting way, that is much more fulfilling and aesthetically pleasing.
- Visit sites, museums and other related cultural areas without actually being to the place

2. Objectives and Theory

In this context we are trying to transform and to appropriate creatively the contents of cultural traditions towards a conception of culture as a realm of unstable and indeterminate possibilities waiting for further exploration and new interpretative horizons. We may actually say that cultural ideal consists basically in an endless process of active and creative interpretations of past productions. The cultural tradition is conceived as a reservoir of living forces that can be experienced only if we free them from the petrifaction exerted during the centuries.

Such 'interactive contextualized narratives' and 'hermeneutic experiences' are in fact stirring the fleeting notion of history and time-travel, based on the new emerging cultural fabric of the 21st century. That results in intriguing possibilities for new digital narratives that will pervade in the information age by raising new issues on cultural heritage representation, interpretation and interaction in space-time.

3. Virtual Heritage Representation Systems

There are three main representation systems to access virtual cultural reality: The first is performed within interior spaces which are especially designed to be **virtual cultural centers**. The second is performed on cultural sites using technologies especially adapted and designed for **on site mobile systems**; these are used for 3D reconstructions of monuments on sites and over the internet. The third is performed by remote users and exists in web presentation techniques that rely on **web information systems.**

3.1 Virtual Cultural Centers

3.1.1 Web3D domains.

The great benefit of Web3D technologies is that it offers tools for creating virtual environments using technologies like VRML (Virtual Reality Modeling Language) and X3D (X3D features extensions to VRML), which are essentially scene graph languages that allow us to create 3D scenes or virtual environments on the web. This allows us to further blend 3D with other multimedia content on the web. Consequently, Web3D has the potential to be applied to a number of different application scenarios, to be provided to the web client visualization interfaces (i.e. web-browser interfaces). The functionality of the web-client as a virtual museum is shown as a thumbnail and associated metadata and information that describes the artifact. The artifact is also publicized as a 3D object and can be manipulated using an input device such as an ordinary mouse or a more advanced interaction device (White,). This extends the typical museum catalogue type interface into 3d rather than just images. Finally, there is an AR link on the web page which when pressed launches the AR application and in effects displays the 3D object in the user’s physical world space (see Figure 1).

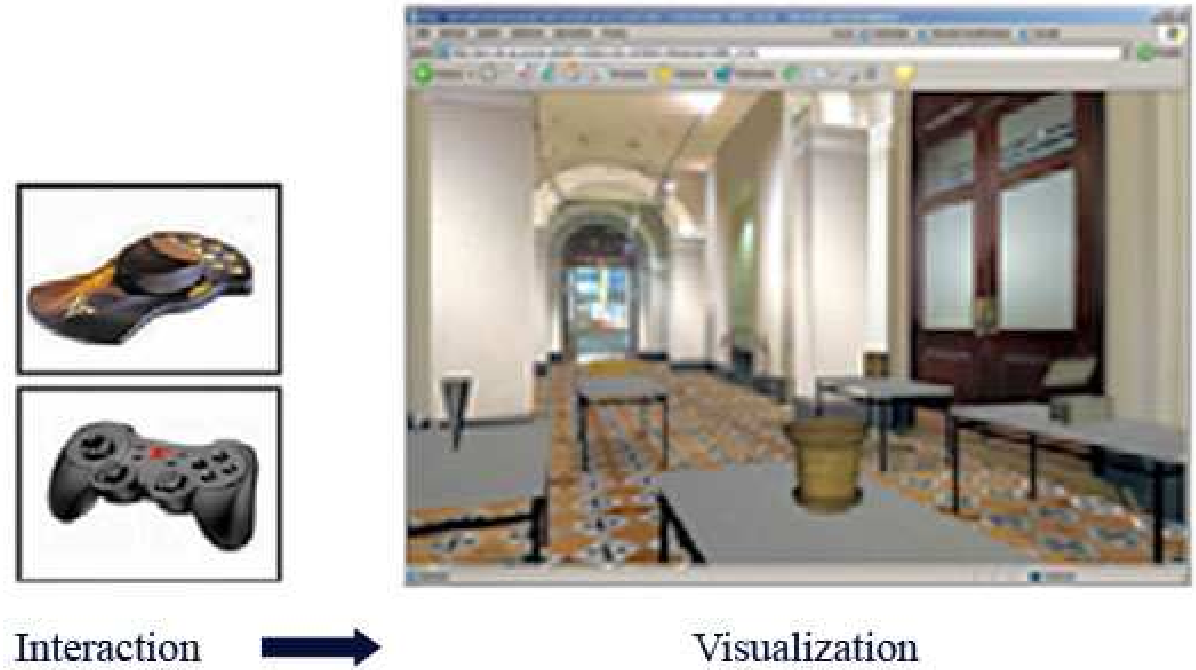


Figure 1: Web3D has the potential to be applied to a number of different application scenarios.

3.1.2 Virtual environment domains.

3.1.2.1 Virtual Museums. It is an Integrating of Virtual Reality and Multimedia Databases for Customized Visualization of Cultural Heritage. By using an innovative approach for querying a database within a VR environment, the user can retrieve and visualize all and only the information he/she is interested to explore (based on his/her interests, domain experiences, etc), and thus he/she has the freedom of fully customizing the visit. Its goals are to provide suitable tools for managing queries entered from the virtual environment and for displaying back the results generating a customizable virtual tour according to user preferences. Users can interact with the system in various moments during the tour: before starting it, to define content and appearance; and during the tour itself, to obtain further information on the displayed artifacts. Among the preferences that can be specified at the beginning the tour, the user has the possibility of choosing the appearance of the environment among different museum architectures, the type of tour (linear vs. not linear) and for how long his/her tour should last. We are investigating three different approaches to control the tour-duration: a rubber-band technique that gently pushes the user from a room to the next one when time goes by; a time-based rollover among the artifacts visualized into the scenes; and, finally, query result priming, based on information stored into the database. All the above user-stated preferences are integrated with information from the curator who based on his/her knowledge, supplies the system with additional information useful to reconstruct historically correct tours (Mazzoleni,). Hence, user preferences and query results are sent to the Scene Builder Engine that is in charge of generating, the customized virtual world (see Figure 2).

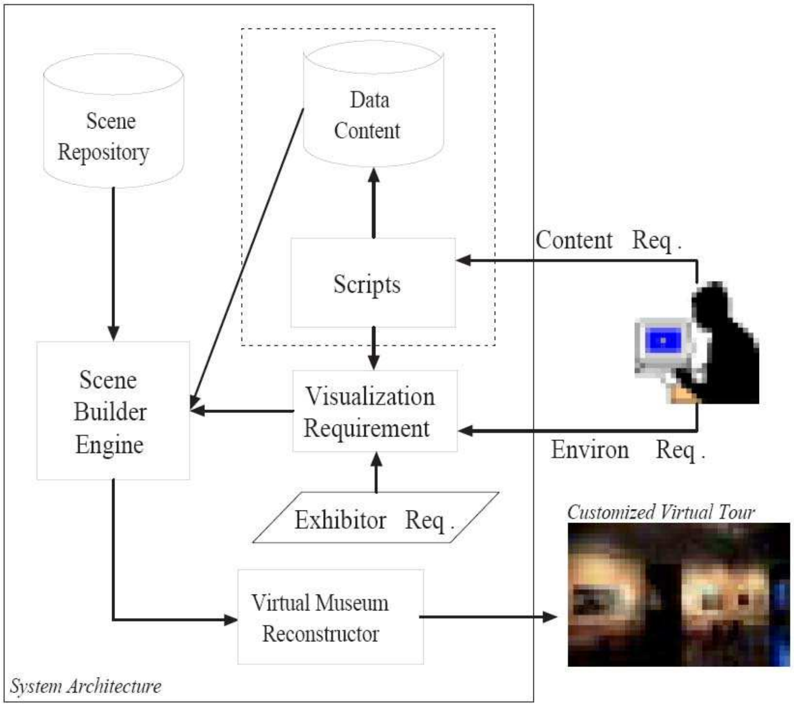


Figure 2: The Scene Builder Engine.

The Scene Builder Engine loads from a scene repository both the rooms' geometry and the virtual objects (frames, columns, etc.) used to wrap the query results before returning them to the user. According to the user preferences and based on number and type of information returned from the database, each scene is resized and dynamically filed with works of arts. The final locations of each artifact into the scene and of each scene with respect to the tour are not pre-computed but again are dynamically calculated based on the area needed to display objects, the one available in each scene and the information from the user.

3.1.2.3 VR theaters. Reconstructed ruins are projected onto a large screen, and visitors enjoy their virtual stroll of the ruins, which actually existed on the other side of the earth. Conventionally, in most ancient civilization exhibitions, excavated articles are displayed and simply explained. However, displays and explanations are not sufficient for most museum visitors to understand the location of the excavation, the extent of the ruins, and the lifestyle of the people at that time. During the virtual guided tour in the VR Theater, the actors operate a game-pad-type controller and give commentary in accordance with the story written for their roles (Hirose, 2006).

When we think of a VR theater, we tend to consider a direct interaction between the audience and VR images (see Figure 3).

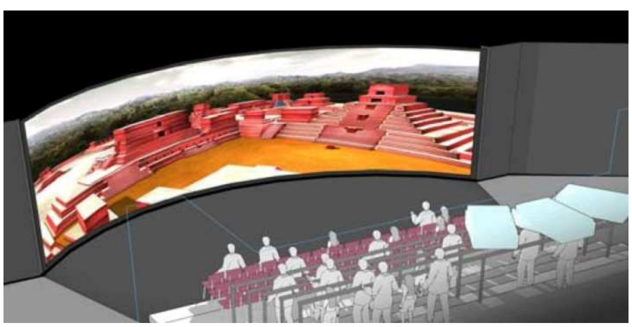


Figure 3: Virtual Reality Theater at National Science Museum-Japan.

3.1.2.3 Visualization Portals and Labs (at UCLA- USA.) The Visualization Portal and facilities like it are commonly referred to as virtual reality rooms or immersive environments (see Figure 4). The term 'virtual reality' was coined and referred to the ability to immerse a person in an artificial, computer-generated, three-dimensional world (up to 45 people).

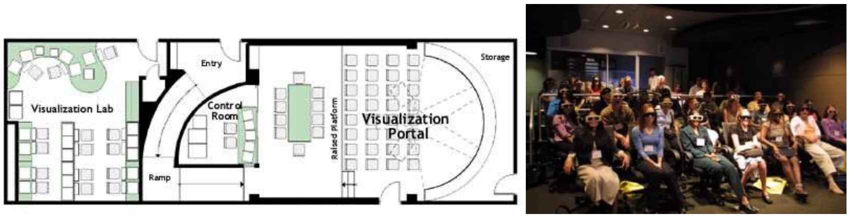


Figure 4: The Visualization Portal and facilities.

Along with the large spherical screen, the Portal offers high performance computing for running and displaying large datasets. These two elements - top notch display and computing technologies - are key to successfully displaying a diverse set of models and applications.
The system uses three ceiling-mounted projectors to display images on the 160 x 40-degree spherical screen (24 feet in diameter, 8 1/2 feet high). This allows up to three simultaneous images (up to 1280 x 1024 pixels each) to be displayed - for example one video- taped image, a PowerPoint presentation, and a computer simulation (see Figure 5). A single image can be created across all three screens by overlapping the three images and blending the edges together, resulting in a 3520 x 1024 pixel seamless display (Fischer, B).

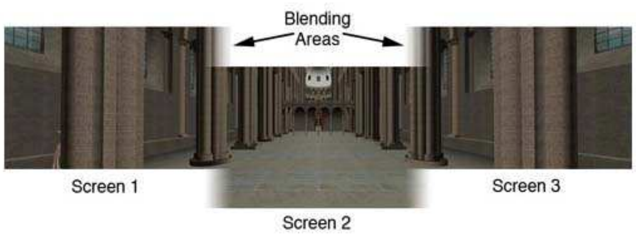


Figure 5: The three simultaneous images.

3.1.2.4 CAVE. The CAVE is a multi-person; room-sized, high-resolution, 3D video and audio environment (see Figure 6). Four projectors are used to throw full-color, computer-generated images onto three walls and the floor. In the CAVE all perspectives are calculated from the point of view of the user. A head tracker provides information about the user's position. Offset images are calculated for each eye. To experience the stereo effect, the user wears active stereo glasses which alternately block the left and right eye. That allows 3-D objects and virtual environments to be viewed with stereo graphics, localized and surround sound, tracking, and interactive object manipulation. Because of highly realistic rendering, immersive technology of a five-side CAVE and a new intuitive interaction paradigm, the presentation gives the visitor the impression of really being on the original site. The underlying goal is always to involve the user into the demonstration. On contrary to traditional information support like books, videos or multimedia CD, the user is invited to live an experience in a realistic environment. Through own experience, a higher understanding and learning effect is reached. For this reason, new technologies like VR and AR are particularly adequate to transmit cultural heritage (Intercom SA,).

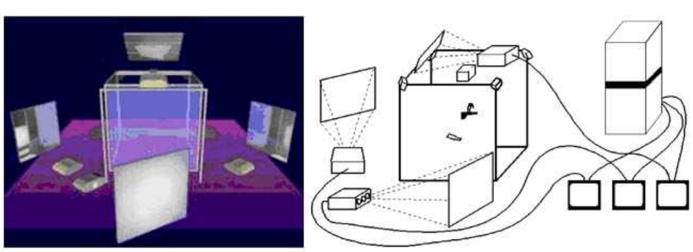


Figure 6: The CAVE is a multi-person, room-sized, high-resolution, 3D video and audio environment.

3.1.2.5. Story telling- Navigation and user interaction. User interaction is done by means of a virtual book created like a historical folio. This book works with a touch-control screen that is integrated into a reading desk. The user can navigate to certain points of interest where he can get additional information. These points can be selected be pressing on the 2d map of the building. When such a point is reached different types of audio visual information can be retrieved. Besides this guided tour the position and viewing direction can be controlled using virtual cursor buttons (Intercom SA,). To prevent the visitor from walking through walls and other solid objects collision detection is integrated **(**see Figure 7).

Figure 7: Interaction and Navigation desk.

3.1.2.6 MUD (Multi-User Dungeon). Through the MUD framework, visitors can create a "double" of themselves in virtual space. By controlling this "double" in virtual space, they can see objects in virtual space, hold "conversations" with the doubles of other visitors or give presentations. MUD space uses the arrangement of actual capsules in the digital museum as a base, but it is not limited to this. It can virtually expand the floors to offer access to the entire collection, including objects not on display. The virtual floors contain virtual capsules. Since the restrictions of Euclidean geometry do not apply to the imaginary floors, virtual capsules which contain related information can exist in numerous locations. In such a way, it is possible to map the position of the hyperlink from a definitive standpoint, arranging the capsules so that they are all "next to" one another (see Figure 8).

It is possible to see the images of actual surroundings of the Exhibit Capsule accessed through virtual space screen. Also, visitors who have entered virtual space through the screens of the real Exhibit Capsules can be projected in virtual space as real images taken by a camera. "Visitors" who have entered the virtual space via the Internet are projected in virtual space as abstract human images, and can "converse" with the other visitors.

While displaying real objects, the Exhibit Capsules also serve as a hyperlink node (in WWW jargon, a home page), and offer an entrance to virtual space (Sakamura, K. 2006).

Figure 8: Visitors can create a "double" of themselves in virtual Space through the MUD framework.

3.1.2.7 Virtual Documentation Systems. Virtual documentation depends on three different sources of information. The first is to obtain the biggest amount of material consisted of different 2D plans available through Museum and scientific institutes. They build the base of the three dimensional model that requires a lot of supplementary work. The second is complete measurements with photogram metric and survey methods. The third is publications and images shot directly on the site to provide eventual missing data. By getting the quantity and good quality of input data, it is possible to reconstruct a very precise and detailed model. One of the most important issues is that the model must be appropriate to real-time VR presentation. It has to be designed in a way that exploits the special properties of the VR-system and the final graphics hardware. The geometry had to be organized in a suitable way and many objects had to be designed with different levels of complexity. This aspect of the modeling is very delicate. The right balance between fidelity to the real monument and technical limits has to be found carefully by archeologists and VR scientists (Inrtacom SA,).

Textures are necessary for a realistic representation of real scene in virtual environment. They are used for all 2D objects, like painting, mosaics, and for material of surfaces like wood or marble (see Figure 9). Another aspect of using textures is the reduction of the geometries complexity. Many details have a 2D characteristic and can therefore be appropriately reproduced by texture images. Because modern graphics hardware is optimized for the use of textures, a very fast visualization can be achieved preserving all the details (Paivio,).

Figure 9: 3D Modeling of Hagia Sophia- Turkey.

3.1.3 Augmented interactivity domains. Interactivity is one of die most important properties in any virtual world. Nevertheless, a distinction may be made between mere navigation in a virtual space and active participation of the user in what happens in it. In the first case, the user adopts a kind of "Comprehensive Eye" position: he may see everything, go everywhere, pass through anything but does not intervene nor have the ability to modify the environment in which he evolves. He is a divine wanderer. The majority of cultural heritage virtual worlds have been designed on this principle. In the second case the user may act either as an extraneous factor to the virtual world or as some one from inside. In any case the user adopts a role in which may be contemporaneous or not to the virtually represented world (Sideris,). In a different VR programme in which the user assembles ceramic sherds in order to restore ancient vases, the user acts as a modem archaeologist who is external to the world represented by the vases themselves in an immersive VR programme (see Figure 10).

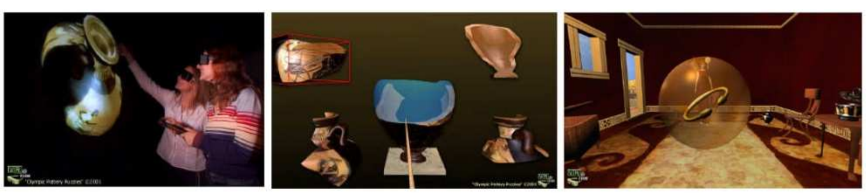


Figure 10: Users act as modern archeologists by assembling the virtual pieces of vases. A user helps virtual character wear jewelry.

Visitors to the museum are able to access data on the server through PDMA (Personalized Digital Museum Assistant) they are carrying, and conversely it is possible to transmit data from the server to the visitor. PDMA is a compact electronic portable device that carries out commentary of the digital museum. Electronic tags are affixed to the exhibits of the digital museum. These tags are then read by the PDMA, and when the user points the PDMA at an exhibit,

the PDMA automatically provides commentary on that exhibit on the screen and by voice. By gaining a clear picture of the location of visitors, the PDMA in its normal state shows the current position in a map of the museum, and displays a guide for the surrounding exhibits. When looking for a particular exhibit, the PDMA shows the route to the display capsule in which it is displayed, and if it is not being displayed, the visitor is invited to a virtual floor from a nearby capsule that is not being used. The PDMA is the means of communication within the museum, not only for visitors but also for museum staff (Sakamura, K. 2006).

3.2. On Site Virtual Systems

That will provide the users the experience of a tour in a cultural site with the ability to view the natural environment, to visualize 3D reconstructions of monuments and be assisted during the view by a multimedia guidance system. The system will address the requirements of a wide user selection that includes cultural site visitors, cultural site managers, researchers, and content creators. Cultural site visitors will be provided with a see-through Head-Mounted Display (HMD), earphone, and mobile computing equipment (see Figure 11).

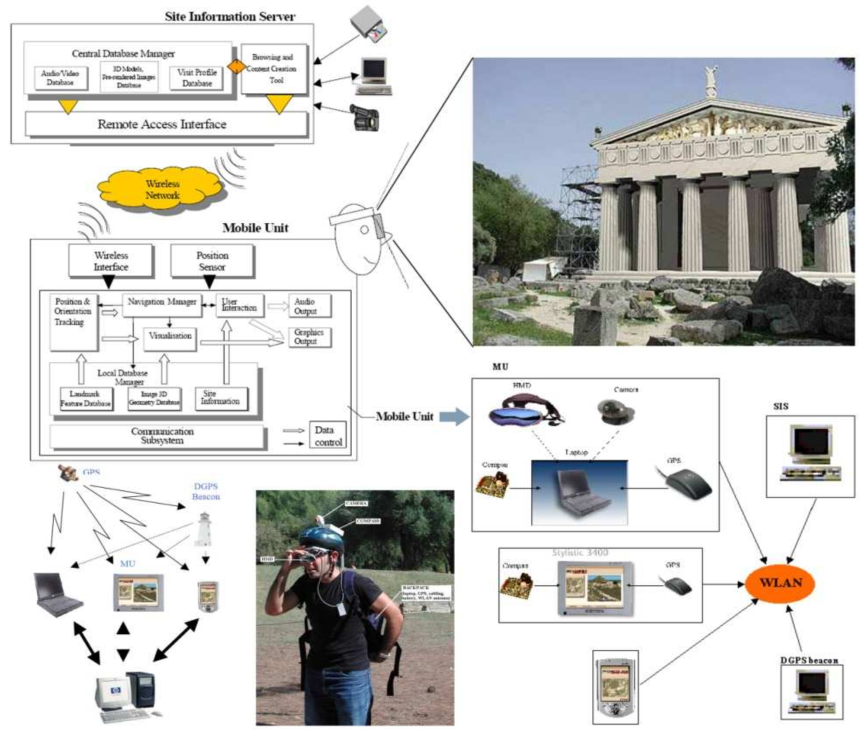


Figure 11: On Site / and Remote Access Interface System

A tracking system will determine the location of the visitor within the site. Based on the visitor's profile and his position, audio and visual information will be presented to guide and allow him/her to gain more insight into relevant aspects of the site (Inrtacom SA,). This system is built on server-client architecture and consists of 3 main functional blocks:

- Site Information Server (SIS): Server including database access module, plus authoring toolkits for site documentation management and tour creation.
- Mobile Units (MU): Client including position and orientation tracking system, rendering software, controller unit, user interfaces.
- Communication Infrastructure.

In addition there is a second server, serving as a reference station for the Differential GPS (DGPS) correction data.

3.2.1 On Site Augmented Reality Tours

Augmented Reality is a new technology that combines real scenes with synthetic objects thus supplements the real environment with 3D representations of objects. In augmented reality tours, the visitors are in the natural site and are able to view also 3D reconstructions of the monuments. This is accomplished through screens that receive the real scene with a camera and augment the 3D models or through HMDs where the visitors walk along the site viewing the surroundings with the addition of virtual monuments in the way they were standing when they were built.

The system comprises mainly a server, a wireless network and a number of client systems that are essentially "wearable computers" including Head Mounted Display with camera and earphone (HMD), lightweight laptop computer and batteries. The end-user (a visitor) "wears" the client unit (called a Mobile Unit – MU) and follows a tour that is customized to match their interests, guided by the system. The client communicates with the server whenever necessary to obtain some information that is not stored in the client's local database (see Figure 12). Due to the low bandwidth of wireless network infrastructures, and due to the very fast clock speeds of the client machines available, to allow scalability of the system, the overall model leans towards a “fat client”. In this model, only tasks that are not categorized as “real-time” or bandwidth-consuming may be delegated to the server for distributed processing. Also the client database manager may submit requests to the server DBMS when an object is not available in the local database. The overall partitioning scheme of the database among server and client follows the “vertical model” where all the rows of some tables are replicated in each database system. The following picture shows the rough architecture of the system (Inrtacom SA,).

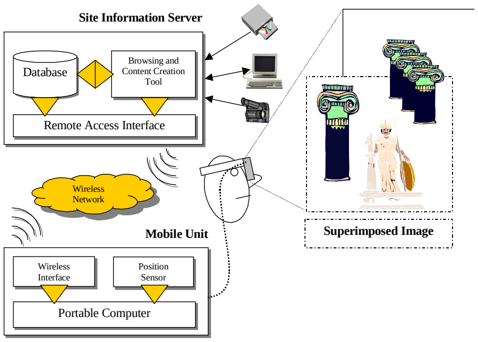


Figure 12: System overview for on site augmented reality tours.

HMDs

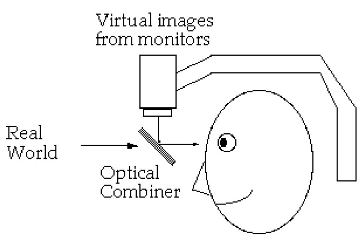


Figure 13: On Site / and Remote Access Interface System

A HMD is a helmet or a face mask that holds the visual and auditory displays. The helmet may be free ranging, tethered, or might be attached to some sort of armature. With the instrumented glove the user can manipulate objects in the computer. Such a glove is outfitted with sensors on the fingers as well as an overall position/orientation tracker (see Figure 13). The concept of an instrumented glove has been extended to the other body parts. Full body suits with position and bend sensors have been used for capturing motion for character animation, control of music synthesizers, etc. in addition to VR applications.

3.2.2 On-site 3D Virtual Reconstructions

It is a computer technology called Time Frame in order to provide on-site 3D reconstructions of monuments in archeological sites and allow the presentation of sites to different audiences without the physical reconstruction of their remains. The Time Frame consists of a fixed video camera, a computer system, two monitors and a touch screen. A booth or “kiosk” protects the system and the visitors.

The camera is directed at a particular section of the archeological site and transmits real-time pictures to the monitor screens (Inrtacom SA,). The system superimposes the real scene with 3D reconstructions of the monuments and displays the resulting scene to the monitor allowing the visitors to visualize how the monuments appeared when standing (see Figure 14).
Virtual reconstruction provides appealing views and insight to cultural heritage sites than more intellectually demanding textual descriptions or drawings and presents several obvious advantages over physical reconstruction including: lower cost, flexibility in handling and preservation, more freedom in taking speculative steps and corrective actions in face of incomplete information. Typically, however, reconstructed sites can be visualized in the confines of a Virtual Environment or computer screen. This will provide the possibility to experience a reconstructed site superimposed within the

real site that is expected to increase the attractiveness and usefulness of virtual reconstruction both to the public and to professionals.

Figure 14: This 3D reconstructions allows the visitors to visualize how the monuments appeared when standing

3.3. Web Information Systems

This system is in some of its applications partially overlapped with the previously mentioned system; i.e. when we are on the web and connected to the **remote access interface** which is a part of the whole on site mobile system (see Figure 11). This technological system has a great benefit towards "digital artistic and ecological heritage exchange" that aims to establish a networked virtual reality infrastructure and content development environment for museums and cyber theaters, for mutual exchange of digital cultural and natural heritage (Hommes.F. 2004).

The relation between cultural heritage and the web already exists in web presentation techniques that can be classified by the nature of examined objects and the methods used for their visualization:

Image: Static images of standalone 2D/3D objects.
Movie: Images/videos of 2D/3D objects placed in a 3D environment.
Model: Visual examinations of individual 3D virtual models.
Scene: Navigation in 3D scenes consisted of many objects.

3.3.1 on the Web 3D Virtual Reconstructions.

Virtual Reconstructions is the most commonly used application of virtual reality in cultural heritage. Using some of the 3D modelling techniques described above, 3D digitization processes or image-based rendering techniques, representations of monuments are constructed and virtual environments are developed. These environments are in some case presented over the internet in light applications and in some other cases as applications on PC's or CD-Rom. In the following we present some organizations and projects involved in this existing area. Virtual reconstructions are mainly performed through the remote access interface located on cultural sites (see Figure 11).

3.3.2 on the Web Interactive Art Museums.

That is to develop an Interactive Art Museum on the World Wide Web so as visitors to the art museum will be able to view two-dimensional images and utilize remote telerobotic devices equipped with video cameras to view three-dimensional works and participate interactively, in real time, in art performances and installations. New techniques in 3D modelling hap tic interfacing and augmented reality will permit onsite and remote inspection and manipulation of three-dimensional museum objects. New systems for text and voice communications implemented in conjunction with the museum will allow visitors to monitor each other's activities, record their own activities, and exchange messages. Exhibits will be structured so as to encourage participation and commitment.

3.3.3 on the Web Virtual Tours.

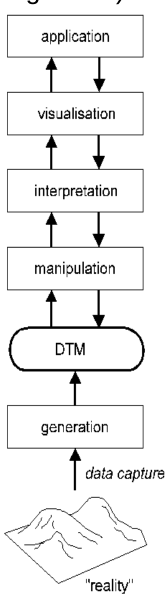
Virtual Tours provide simulation of tours on sites over the internet, 3D reconstructions of monuments that are ruined on sites, or both tours over internet with 3D representations of objects that existed on a site. In the case where are presented over the internet, virtual environments are developed that simulate the real site and can even provide visualizations of the monuments in the way they were built. In the case of an on site virtual tour, 3D reconstructions of artefacts are given in computers that are placed in the site or in mobiles that the visitors carry with them (Zara, J. 2004).

3.3.4 VR WebGIS: Landscape Generation.

It is a system created for the reconstruction of the archaeological landscape, in a process that has to take into account the different phases of digital processing, helping to explore the relations between data processing and data representation, between observed landscape and reconstructed landscape. The system is based on two open projects: Open Scene Graph library **[**Open Scene Graph] and Virtual Terrain Project [www.vterrain.org]. They were used in combination, modifying partially the code and adding plug-ins, in order to create tools useful to reconstruct complex landscapes, starting from GIS data-Source data.

The availability of high quality tools for processing and representation of input data is crucial for successful process based modelling. Most inputs for distributed models are given by functions, which depend on the position in 3D space and time. While the standard 2D raster maps suggest an acceptable Digital Elevation Model (DEM) quality for most of the interpolation methods applied to the test data, viewing the results as surfaces with lighting and shading reveals serious distortions in surface geometries. By identification of deficiencies in interpolation techniques, visualization of interpolated fields as lighted/shaded surfaces in 3D space, rather than 2D contours or colour raster maps, has contributed to the development of significant improvements in interpolation methods and algorithms.

A high level of interactivity ensures the efficiency and suitability of visualization tools for exploring multi-variate land characterization data by a combination of advanced visualization capabilities with the traditional spatial query and analysis functions of a GIS. In an effort to expand some of the interactive visualization capabilities to users accessing the cartographic models, it is possible to translate georeferenced raster data to Virtual Reality Modelling Language (VRML) format files (see Figure 15).



The advancements in the GIS and computer graphics technology are making dynamic cartography a practical tool supporting complex landscape simulations. Availability of digital georeferenced data and capabilities to distribute images and animations through the computer networks expand the role of computer cartography from automation of paper map production towards providing methods and techniques aimed at exploration and communication of georeferenced data and their spatial and spatio-temporal relationships. This enables us to utilize general techniques of scientific visualization for new approaches to analysis, presentation and distribution of geo-referenced data. Further development and wider applications of the cartographic visualization techniques will be driven by full integration of multi-dimensional data structures and their support within GIS, by larger volumes of spatio-temporal data available and by improvements in speed and quality of graphics on personal and wearable computers (Pescarin S. & Calori L., Camporesi C.2005).

Figure 15: The main tasks of a digital terrain modeling system.

4. Case Study: Mixed Realities for the world of Islamic Art, Architecture and Urbanism

Since antiquity, images were used as records of both events-lifestyles, as well as decorations. The possibility of reviving them will add a new dimension in understanding our past. Potentially a Virtual Reality-based heritage experience gives the visitor die opportunity to feel they are present at significant places and times in the past and use a variety of senses to experience what it would have felt like to be there (Papagiannakis,).

We understand “virtual reality” as implying the use of three dimensional computer graphics in a system that is (at a minimum) real time, immersive, and interactive. An important distinction should be made between VR and computer graphics (cg), with which VR is some times confused. While all VR could be called CG, not all CG constitute VR. The difference is that, whereas CG is simply “pictorial representation of objects and data uses computers”, VR is CG requiring immersion, interactivity, and a real world delivery system (Fischer, B. and Ryan, N.).

Thus, we need new database/interface environment, that represents 'locations, links' within the fractal hierarchies of database. It is a hybrid environment, superimposed **real-world environments** and **virtual environments** which offer the user a multitude of interactions, visualizing, and multi-layered info-structure. When we talk about databases we do not necessarily mean a distinct set of collected data, but rather a conceptual framework which includes all such data which are accessible by some means (Irie, K.1996).). These are **2D/ 3D environments** which represent a given set of data in a form dynamically modeled for a specific user {viewpoint}. The goal is to build systems which are {user-centered}, adaptive and support a maximum of appropriation/ customization by the user.

This case study is a proposal for a **comprehensive system** for Cultural Virtual Reality concerning Islamic Art, Architecture and Urbanism. Here we are introducing a virtual world that combines the power of VR (Virtual Reality) and 3D Information Visualization, Augmenting VEs with additional abstract information such as text and graphs.

3D Information Visualizations take a complex and abstract datasets and organize it into an understandable visual presentation, which can be navigated and accessed by the user. Here abstract properties of the data are mapped into perceptual qualities, such as position, orientation, size, shape, and relationships between pieces of data are represented spatially. The resulting multi-dimensional visualisation can reveal patterns in the data that may not be obvious from the original datasets (see Figure 16).

This **comprehensive system** ends with three main types of interactive knowledge presentations: **1. Virtual Cultural Centres, 2.On Site Mobile Systems, 3. Wed Information Systems.** Within the Virtual Cultural Centres participants can switch dynamically between virtual web-based environments to indoor augmented reality environments as well as make use of various multimodal interaction techniques to better explore heritage information in the virtual museum. The museum visitor can potentially experience their digital heritage in the physical sense in the museum, then explore further through the web, visualize this heritage in the round (3D on the web), take that 3D artifact into the augmented reality domain (the real world) and explore it further using various multimodal interfaces. The system aims in educating the visitors about artifacts and their history. This project could develop 3D multimedia tools to record, reconstruct, encode and visualize archaeological ruins in virtual reality. These tools could be applied to buildings, building parts, pottery, terrain geometry, textures and texture materials (see Figure 17).

A multimodal mixed reality interface can be exploited to provide several different and interesting types of virtual heritage exhibitions. The novelty of the technologies employed is that they allow users to switch between three different types of visualization environments including: the web in the traditional way, but including 3D, virtual reality and augmented reality (thus mixing these different formats into the same architecture). Additionally, several different interface techniques can be employed to make exploration of the virtual museum that is much more interesting.

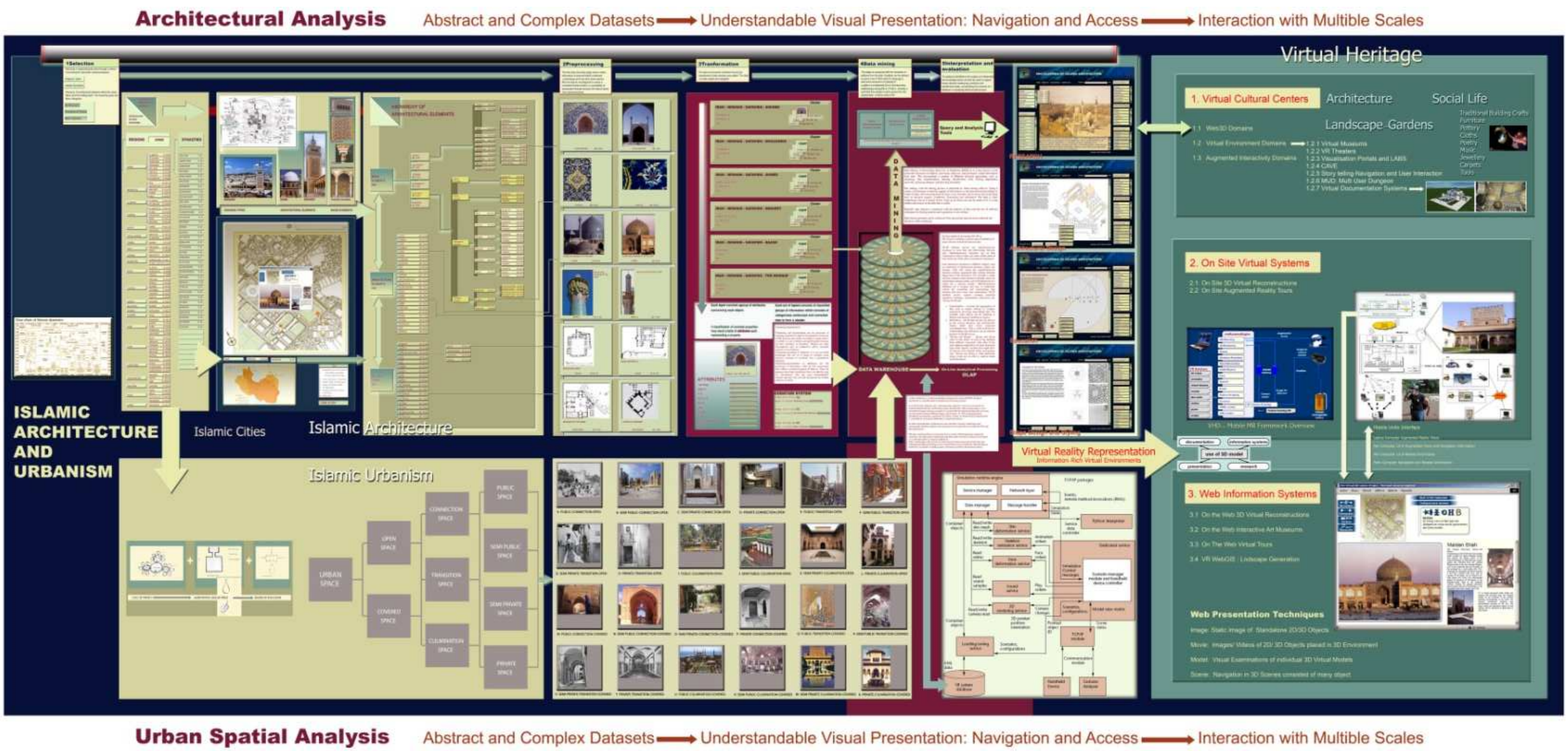


Figure 16: A comprehensive system for Cultural Virtual Reality cocerning Islamic Art, Architecture and Urbanism

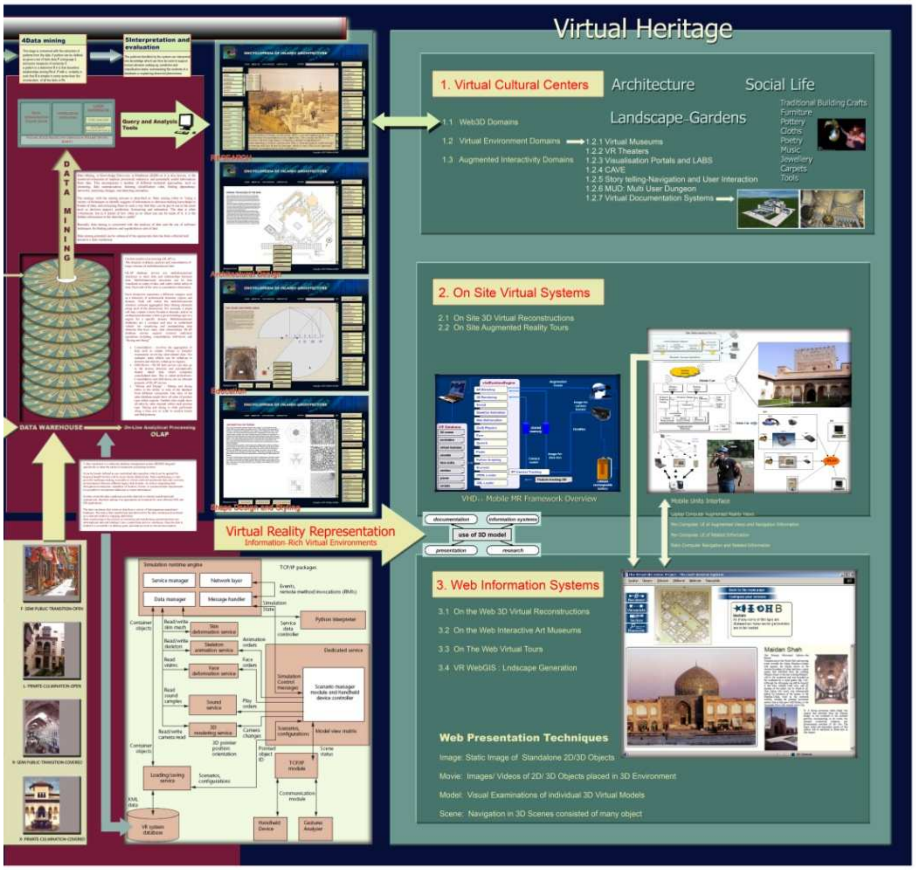


Figure 17: Use of various multimodal interaction techniques to better explore heritage information.

The proposed multimodal mixed reality interfaces allows users to transfer 3D information (3D artifacts and metadata) over the internet and superimpose them on an indoor AR environment as well as interact with the artifacts in a number of different ways using several types of interaction device.

Virtual Cultural Centres provides an immersive virtual environment that allows the visitors to virtually explore the building (element), to experience its architecture, dimensions, and atmosphere, and to obtain architectural, cultural, and historical information as well. Navigation and interaction in the scenario are realized by an innovative man-machine interface that can be operated intuitively. A virtual guide, in traditional clothes, talks to the visitor and gives him explanations about the building. The presentation is done in real-time on a stereoscopic large-screen projection.
Thus, even large groups can participate. In order to achieve a high degree of immersion, the visual representation is complemented by sounds and background music.

Today, the forward march of technology has quietly enabled a second wave of VR applications, with reality finally beginning to live up to its title role. Digital tools and techniques now emerging from academic, government, and industry labs offer new hope to the often painstakingly complex tasks of archaeology, surveying, historic research, conservation, and education. These emerging second-generation technologies can be grouped into three domains:

- 3D documentation (everything from site surveys to epigraphy),
- 3D representation (from historic reconstruction to visualization), and
- 3D dissemination (from immersive networked worlds to "in situ" augmented reality).

Conclusion and future work

In order to design a future for virtual reality we need to:

- Enhance Digital technology for research and education and the ways archaeologists and researches have for visualizing, reconstructing, and exploring virtual sites.
- Contribute the virtual heritage projects in the development and deployment of new technologies that will provide more natural ways of interacting with computers and accessing information in electronic form. Virtual heritage projects will make the interpretations of history more accessible to the general public, and at the same time narrow the individual's scope for personalized, interactive experience and visualization of the description of it.
- Attract more people to cultural heritage sites and boost investment in digital representation of cultural assets. This will enable the exploration of new ways to present cultural heritage information to people of different cultural backgrounds, and especially children.

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