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ViSMan: an Open-Source Visualization Framework for Virtual Reconstructions and Data Management in Archaeology

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Abstract

This paper aims at analyzing some case-studies in Virtual Archaeology where 3d reconstructions have been used as a tool for visualization and spatial organization of structured archaeological data.
ViSMan (Visual Scenarios MANager) is an open source framework developed at Cineca for the visualization of scientific virtual environments. It has been applied to several Virtual Archaeology projects, thus allowing advanced 3d visualization features, switching between models, and linking to external contents such as images, text files, web urls; data linked through the models are visualized by the user in a new frame, overlapping or separated from the browser.
1. VisArq. 1.0 is an online geo-database of the archaeological heritage of the area around Zaragoza, Spain; the whole territory is visualized in ViSMan as a 3d DEM (Digital Elevation Model); the model displays the distribution of archaeological sites for which some kind of external reference is available; access is provided to different types of data by means of interactive HTML pages.
2: DHER-ViSMan application (running off-line) encloses both photo-realistic and schematic reconstructions of roman houses in Herculaneum, and explores different levels of data, ranging from the regional area to a single wall-painting; each model contains "Nodes", which provide access to a rich archive of data, managed through a relational database.

Categories and Subject Descriptors (according to ACM CCS): I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Virtual Reality I.3.8 [Computer Graphics]: Applications

1. Introduction

The video-game market, and recently some service industries like GPS navigation, through intensive usage of 3d graphics, gave a strong momentum to the spreading of low-cost graphic hardware, consoles and interaction devices, which can be used for scientific and historical purposes as well. As a consequence nowadays a common PC has a graphic computing power in many ways superior to that of expensive supercomputers from few years ago, and most recent laptops are powerful enough to handle real-time 3d graphics. Even display systems are available at a significantly lower cost than in the past: rear projection screens, with the possibility of stereoscopy, are now within the reach of medium-sized museums and small municipalities.

This is a technical revolution, making it possible for any institution, laboratory or Public Administration to use Virtual Reality for communication purposes, while in the past costs were unsustainable almost for everybody.

With the wide diffusion of this kind of applications, new needs have been rising from the scientific community. For example, until some years ago no commercial software had been specifically designed for Cultural Heritage applications, nor allowed to extrapolate information from 3d objects during navigation.

A visualization software applied to Cultural Heritage and to reconstructed landscapes needs to display this information, otherwise the reconstruction would be lacking any additional content, relying solely on the 3d models.

Information related to the models witnesses the research activity behind the reconstruction, thus providing evidence of scientific, historical, cultural or archeological quality of virtual contents. A 3d model, on the other hand, can fully exploit any information, contextualizing the objects to which it relates.

To meet this specific lack, CINECA developed

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ViSMan (*Virtual Scenarios Manager*). ViSMan was designed ad hoc to fill this gap and proved its effectiveness in many cultural and scientific applications [BCD*04].

2. A tool for Virtual Archaeology

ViSMan (*Virtual Scenarios Manager*) was developed with OpenScenegraph library, that is available for Windows and Linux operation systems. The chosen development language was C + +, because it allows low-level operations that are sometimes necessary to handle 3d graphics. It is also one of the languages with greater efficiency in the generated code. The software project was written in Cmake, allowing compilation in various development environments and operating systems: Microsoft Visual Studio on Windows, on Linux Make and KDevelop. A first GUI has been designed with the open source library WxWidgets. While creating ViSMan we tried to use open source libraries for all its functionality, but also to make it "portable" to other platforms and hardware systems.

ViSMan is basically an advanced viewer for 3d data, with some additional features that facilitate the use of virtual reconstructions as tools for researchers. Navigation through the model is intuitive, "video-game like", with both fly-through and walk-through function. ViSMan allows the creation of meaningful points of view, and gives the possibility to assign names to them and create an automatic path between saved points. The navigation can be made completely automatic by writing scripts of actions. Ground and solid collisions are handled within the 3d world, background sounds or return sounds can be added to specific events; Image Based Rendering is supported. The most interesting point of view for navigation is the first person because it allows the user to feel immersed in the visualized environment. The sense of realism is enhanced by the collision management, that is, the impossibility of going through objects and walls, and the ability to follow uneven terrain like stairs - very common in historically interesting buildings - ramps and descents. This reproduction of the actual behavior allows greater immersion in Virtual Reality, therefore greater user involvement.

A major innovation in concept and in usage of virtual reconstructions is the introduction of links between 3d objects and relational databases (Access, Oracle, SQL Server, etc..); it opens a new frontier of knowledge by providing access to all information cataloged and available for each particular object reconstructed in 3d. Of course this kind of application requires a strict homogenization and normalization process on data, so that they can be treated with a common interface.

3d objects in the scene can be connected to relational databases, that means by clicking on object or part of it on the stage, you can open a link to multimedia contents (HTML, text, images, videos, web-pages or anything else), visualize data in a custom format and connect to remote databases through the Internet. In reverse, you can generate polygonal writings into the scene starting from database text records, create colored labels to identify different types of nodes, or just search objects in the 3d model selecting them from the database. You can browse the 3d world by querying data in the database, that is, reconstruct a virtual path in the simulated world starting from a sequence of data attached to it. This allows you to perform searches on the data (querying the database) and then see where the object these data apply to is placed in the 3d model. 3d models and database are closely intertwined, and either can be the starting point for the fruition of content.

A typical application could be that of a Virtual Museum, having at disposal a form for every exposed artwork, with information on the work itself (year of achievement, author, style and period, etc..); at the same time, this document could link to a form with detailed information on the selected author, then in general to the authors whose works are exhibited in the museum. In this way the virtually reconstructed object is only the starting point for a number of insights concerning both the object and its context.

This possibility is highly innovative and allows you to go beyond the simple three-dimensional reconstruction of sites, enabling a much more complete fruition of contents than do classic Virtual Reality applications, enabling view-only navigation.

Another feature recently introduced is the possibility to visualize - inside the reconstructed Scenario - the result of dynamic scientific visualizations and simulations. This is another important step toward actual use of Virtual Reality application as a research tool.

A first example of scientific simulation inside ViSMan was developed for the European Research Programme Exploris, coordinated by Istituto Nazionale di Geofisica e Vulcanologia [BCC*06]. In order to assess the danger of a new eruption of Vesuvius, a scenario was developed that simulates a three-dimensional reconstruction of volcanic columns and pyroclastic flows. The simulation covers the first 1500 seconds of an eruption, within an area of 12x12x8 km3. The virtual simulation is enhanced by integration with the DEM of the territory and with GIS layers of geographical and historical data. Reconstruction of the territory contributes to a better understanding of the eruption.

It is a key point to plan an open and extensible software architecture: this can make it possible to visualize models and data in the database as soon as they are made available by researchers, and to integrate them anytime you want. The expansion may be related either to virtual models or to related information inside the database.

A feature of great interest for this class of applications is the possibility to switch between alternative historical models, each one with its database linked to it, in real time.

This allows researchers to simulate and visualize the different historical periods of a site and its various developments over the centuries, changes, expansions, etc..

up to the current situation. Instead of simply examining a 3d reconstruction of ruins, it would be possible for instance to show how reconstructed structures looked like while still standing. In alternative, switching can concern different hypotheses, or reconstructions with different status (e.g. what is surely known, and what is hypothetical), with strong implications on perceived reliability and authority of virtual reconstructions as scientific communication tools.

3. Previous communication experiences developed at VisIT Lab, CINECA

VisIT Lab experimented in the last years various solutions for scientific communication by mean of ViSMan based Virtual Reality applications.

Researchers today have to deal with new communication paradigms and media, and to get closer to languages and channels used by a wider public.

It's now possible to implement virtual applications for different output devices, ranging from palmtop devices to the Web, from video streaming to Virtual Television Sets, to sophisticated immersive environments for the set up of museum installations that communication experts would define "emotional". This kind of initiatives usually requires the ability to collaborate with specialists from other fields and to put together well-built teams.

Two interesting experiences realized with the use of ViSMan were the documentary "High-tech Pompeii", and the exhibition "Living in the Middle Ages, Parma at the time of the cathedral".

As for the realization of the documentary, a join-effort between RAI (StudioTV1, Milan) and CINECA, framed in the RVM4VSET Project (Research Advanced Models for Virtual Set Usage) allowed to achieve examples of television production with Virtual Set. A didactic and dissemination product was realized by mean of virtual models, that had been realized for scientific and historic projects in the VisIT Laboratory at CINECA. Through the use of a Virtual Television Set, real actors recorded in a studio appeared to be walking inside the virtual model of the House of the Centenary at Pompeii. A professor from Università di Bologna, D. Scagliarini, was interviewed by the presenter inside the model and explained the reconstruction process and the historic use of the structures.

Instead for the exhibition "Living in the Middle Ages. Parma at the time of the Cathedral", virtual 3D models, realized with philological care, were used as backdrops in staging special events to describe daily life in the medieval period. Professional actors - coordinated by the multimedia communication company Studio Azzurro - performed religious rituals the way they have been reconstructed by historians, inside the virtual model of the cathedral, and enacted common people throughout a normal working day in the main square of the city. Their performance were recorded and three projection installations were later staged for the exhibition, getting the public to an imaginary journey through time.

These experiences highlighted the possibility to transform philological models into didactic spaces and into engaging narrative for the general public.

4. Research experiences: 3d models as 3d archives for management of heterogeneous datasets

Not only Virtual Archaeology can be an effective means of communication towards scientific community and general public: it can also be a useful tool for researchers in the first stage of analysis, since it allows presentation and visualization of data in a very intuitive and synoptic way. It may as well highlight unexpected characteristics or relationships inside the reconstructed space, and it has the advantage of visually preserving context information.

Virtual models can be eventually considered as 3d archives and used as a graphic and spatial interface to access any kind of structured data systems. This was actually the main purpose for many projects undertaken by VisIT Lab in the last years.

4.1. VisArq. 1.0.: Archaeology and Virtual Reality in the Province of Zaragoza (Spain)

The main focus of VisArq. 1.0. Project was the creation of a database of archeological evidence in the province of Zaragoza and the implementation of a 3D visualization system for the whole area.

The final result is a geo-database displaying the archaeological heritage of the province in a straight and interactive way (Figure 1.). VisArq. 1.0. covers a wide spatial and chronological range of data, going from detailed analysis of archaeological materials to general survey of the landscape where finds are located.

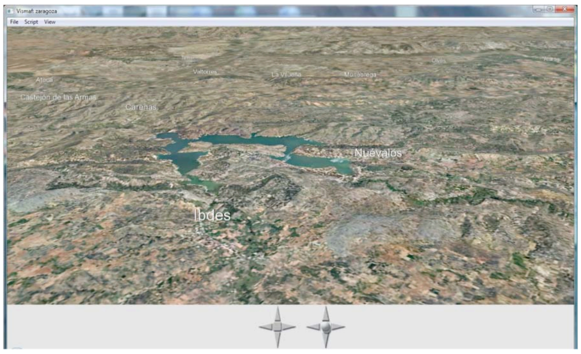

Figure 1. *Screenshot of the DEM in VisArq. 1.0*

Such a wide perspective can only be achieved through new technologies, allowing us to handle a great amount of historical information at different levels of detail.

In brief, we fulfilled four main basic tasks:

- design the database;
- create the Digital Elevation Model;
- create the HTML interactive forms;
- connect, manage and display the information through ViSMan;

Connection is not an easy task. No commercial software had been optimized for Cultural Heritage applications, nor could fulfil our needs. Instead the open software ViSMan had been specifically created for the management of Heritage data. ViSMan allows navigation of DEM as well as 3d models and GIS information layers (Figure 2.)

We chose HTML as a programming language for information contents, mainly for its lightness and especially because it would enable uploading the final dataset to the Internet, making it better accessible to all interested users.

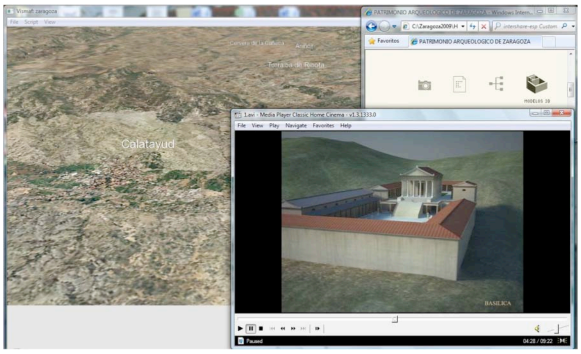

Figure 2. *Screenshot of the DEM and data visualization in VisArq. 1.0*

Such a wide perspective can only be achieved through new technologies, allowing us to handle a great amount of historical information at different levels of detail.

ViSMan was created with the open source graphic library OpenScenegraph, a cross-platform and cross-media solution; this is particularly important for our product, that will be accessed both on a virtual support and on common PCs at home or in interpretation centres.

ViSMan therefore permits navigation through the different elements composing the application, like the database, that can be visualized, queried and browsed in a straightforward way, with great ease of use while preserving the complexity and scientific nature of sources.

In summary, VisArq 1.0. acts like a 3d navigator across the province of Zaragoza, displaying the landscape peculiarities and giving access to the archaeological information.

The implementation of a system for management and three-dimensional display of data, like VisArq 1.0., should become a propositional idea for local and regional development. Such an initiative could support Heritage preservation, by using the application as a platform for sustainable development planning in the area, at the same time promoting and reinforcing social, economic and cultural structures.

4.2. ViSMan-DHER: virtual reconstructions and archaeological data from Herculaneum (NA)

The DHER Project, carried out by Università di Bologna as part of the Vesuviana program (started in 1997 in collaboration with the Soprintendenza of Pompeii and Naples), is a wide analysis and documentation campaign aimed at acquiring better comprehension of housing culture in Herculaneum (NA), in the historical area of Vesuvius. Some houses in Insula III, like the House of the Skeleton, were studied more in depth, and under many aspects, ranging from wall decorations to preservation status and archaeometrical analysis of finds.

After many experiences with ICT applications for Cultural Heritage over the past decade, combining interactive virtual environments and databases, the Domus Herculanensis Rationes (DHER) research project introduces an additional challenge. This is an extremely complex archaeological intervention, providing an unique opportunity to develop and test the effectiveness of interactive virtual environments as a support for systematization of archaeological data. Data for the DHER Project were particularly disaggregated and inhomogeneous, so the challenge was to standardize and frame them, making them available from a common interface in an open system that allowed you to choose what to include.

Currently the most effective way to view and organize complex and strictly interconnected information is to embed it into a database. This was the first step of the project, perfectly matching the requirements of ViSMan.

The main purpose, besides the mere collection and organization of material, was to to reconstruct the original contexts of finds, especially floor and wall paintings, which now lie in museums and could be replaced, at least virtually, in the place they were removed

A virtual navigable space thus seemed particularly appropriate for this type of project, although it was necessary to develop some new features to meet the complexity of the DHER project. The realized system, while dynamic and user-controlled, could present requested data, according to visualized levels or objects (Figure 3.).

Figure 3. *Navigation through the reconstructed Scenario "Herculaneum" with superimposed visualization of associated data (ViSMan software)*

In the realized prototype, a natural and contextualized synoptic fruition of data is proposed, not only directed to scholars but also for the communication of research results to the general public. With regard to usability, the application offers the users the opportunity to decide their own path of study, according to the results obtained, and the researchers an application that can gradually grow, expanding or deepening along with a certain domain of knowledge.

The following categories of data were included in the application:

- Photomaps of decoration details;
- Analytic description of decoration details;
- Excavation journals;
- Photographs of finds;
- Analytic description of finds;
- Graphic documentation from the Archive of the Soprintendenza;
- Modern (Foglia, 1992) photographs from the Archive of the Soprintendenza;
- Historic photographs from the Archive of the Soprintendenza;
- Restoration reports from 1996;
- Photomap of wall faces from survey data;
- Masonry Stratigraphic Units (USM) from survey data;

All these documentary resources - both coming from archives and from the field survey and excavation activity - were included in the database and organized into different tabs. Microsoft Access was chosen as a relational database for convenience. Any relational database working on a PC or server, could be chosen, with the only requirement of ODBC (Open Database Connectivity) libraries availability: this feature is required to connect any third application to a particular database without having to buy any additional license of the software used to create the original database.

Virtual models were realized from architectural and topographic data, obtained from apposite survey activity, using at first Autodesk AutoCAD and Autodesk 3D Studio Max, then Blender. Virtual models were eventually converted to OSG format and optimized for real-time. For ViSMan to actually create the hierarchy of information and the connection to the database, Nodes need to be named within the graphic file. With the word Node we mean a logical grouping of polygons relevant to the model, working as meaningful point of connection between the environment and the database structure, while a Scenario is a whole virtual environment that has been modeled, like for example a city.

Some different Scenarios were modeled for ViSMan-DHER Project: the region territory digital elevation model (DEM), a general view of the archaeological area of Herculaneum (Figure 3.), a detailed model of the so-called House of the Skeleton (Figure 4.), and schematic models of other houses.

Figure 4. *Navigation through the reconstructed Scenario "House of the Skeleton" with superimposed visualization of associated data (ViSMan software)*

Using ViSMan switch feature, it is possible to navigate through this hierarchy and to retrieve relevant information at every level. This means that in the planning stage it is possible for the researcher to decide which Scenarios to assemble, and which levels of information to make available for each one of them. The final user can easily operate the choice among available data through an interface that shows the available databases. For example, Scenario "Archaeological area of Herculaneum" includes Nodes Insula III, House of the Skeleton and House of the Bronze Herm. Data available for each Node in this Scenario are the ones (like Photographs, or Graphic Documentation) that are associated with the whole building. Instead, Scenario House of the Skeleton is a detailed and realistic model of the structure, and data available in this Scenario are associated to single wall surfaces (USM, Photomaps, Analysis of decoration details...).

The inclusion of other types of data is not precluded and especially we imagine links to web pages of museums where material taken from the excavation is conserved.

The system was designed to give access to other digital products dedicated the same geographical area, unifying resources from various sources, such as other virtual reconstructions, databases and collections.

A major advance for the next years would be giving access to this kind of 3d applications across the Web.

5. Future perspectives: data management and dissemination on the Web

The two presented case-study projects are different under many aspects, and required flexibility in the use of ViSMan architecture.

In the DHER project the analyzed context is much more complex and required a division into levels for a correct attribution of data to Nodes. Virtual models - structured into Scenarios - have a central role here, acting as a common interface for access to data and an ontology for better understanding their origin and relationships. Data can be managed through a local relational database, they may only be visualized one by one and no internal query into the database is allowed.

As for VisArq. 1.0, the virtual reconstruction was much simpler, consisting in the plain DEM of the territory with no further Level of Detail to explore, but on the other hand a HTML interface was developed for the visualization of data, that are hosted in an online server.

Data management through the Web - even if by now the model visualization part is still running off-line - is a great achievement. It allows great freedom in content organization, in the choice of formats, and easier interface personalization through HTML or similar languages, and makes remote data sharing easier. Now, the matter of data sharing and diffusion is a key issue for Cultural Heritage, that is often dealing with copyrighted material and with Intellectual Property. Fortunately, many new tools have been developed for Digital Rights Management [Ron09], like for instance access control systems, copy protection systems, watermarking, encryption and well-structured worldwide legal tools like Common Creative licenses (http://creativecommons.org/).

6. Conclusions: towards an Open Heritage knowledge model

The application of ViSMan to different scientific and archaeological projects revealed a major need in the field of Virtual Reality, and more specifically in Cultural Heritage research: a renovation in workflow and in data management is necessary.

Co-operation and contamination between branches of science and culture are necessary to increase awareness and stimulate creativity, but above all dialogue between different languages and interaction with other disciplines are essential to transform research activity from multidisciplinary to truly interdisciplinary.

The old traditional model - strictly embedded in the academic working environment - is based on individuals or small groups with exclusive access to data; the new one instead leads to collective management of knowledge and shared development. In other words, we have to switch from a cathedral to a bazaar-like knowledge model (http://www.apogeonline.com/openpress/cathedral).

Open software development and Web 2.0 tools, services and contents are the best expression of a new model, and the Web is the necessary backbone for open source teams and communities.

It's fundamental to spread open source perspective into the world of culture. Today, open systems are spreading in many sectors, producing a renewal and redefinition of the practices of large private companies and major research institutions in the name of a less hierarchical and more innovative research and entrepreneurship. The idea of developing open systems is particularly fascinating in those areas, such as Cultural Heritage, in which economic resources are scarce and must be used in a conscious and controlled way. The adoption of an open bazaar-like model brings several advantages, not only lower costs but also sustainability, better digital preservation, resource sharing, easier reuse of contents, investment in human resources instead of hardware and software development.

This is the only way we can think about future for research and culture. Through the passage from the élite culture of few people to Open Heritage: knowledge for everyone.

References

[ADD*09] ALVISI C., DELLI PONTI F., DIAMANTI T., DIARTE BLASCO P., GUIDAZZOLI A.: Scenari virtuali interattivi e dati multi-dimensionali per il progetto DHER, in CORALINI A. (ed.) *Domus Herculanensis Rationes, I - Sito archivio museo*, AnteQuem, 2009, 411-427

[BCC*06] BISSON M., CALORI L., CAVAZZONI C., DIAMANTI T., DELLI PONTI F., ERBACCI G., ESPOSTI ONGARO C., GORI R., GUIDAZZOLI A., IMBODEN S., MENCONI G., NERI A., PARESCHI M.T.: An Interactive Virtual Environment to communicate Vesuvius eruptions numerical simulations and Pompeii history In *ACM SIGGRAPH 2006* (2006)

[BCD*04] BORGATTI C., CALORI L., DIAMANTI T., FELICORI M., GUIDAZZOLI A., LIGUORI M. C., MAURI A. M., PESCARIN S., VALENTINI L.: Databases and Virtual Environments: a Good Match for Communicating

Complex Cultural Sites. In *ACM SIGGRAPH 2004*, (2004), 30

[CGM*03] CORALINI A., GUIDAZZOLI A., MALAVASI M., RAFFA G., ROFFIA L., SALMON CINOTTI T., SCAGLIARINI CORLÀITA D., SFORZA F., TABONI C., VECCHIETTI E., Archeologia virtuale e supporti informatici nella ricostruzione di una domus di Pompei, *Archeologia e Calcolatori* 14 (2003), 237-274

[DDD*?] DELLI PONTI F., DIAMANTI T., DIARTE BLASCO P., GUIDAZZOLI A., SEBASTIÁN LÓPEZ M.: VisArq. 1.0.: Interactive Archaeology and 3D Data. In JAVIER MELERO F., CANO P., REVELLES J. (ed.): *Fusion of Cultures. CAA 2010 Proceedings, Granada 6-9 apr 2010* (in press)

[Dia07] DIARTE BLASCO P.: The DHER Project - *Domus Herculanensis Rationes* - and Virtual Archaeology. In *Science and Supercomputing in Europe. Report 2007*, (2007), 728-731

[Gui01] GUIDAZZOLI A.: Experiences of Immersive Graphics for Cultural Heritage. In NICCOLUCCI F. (Ed), *VAST 2000. Proceedings of the VAST Euroconference (Arezzo, 24-25 nov 2000)* BAR International Series 1075, 89-92

[Gui07] GUIDAZZOLI A.: L'esperienza del Cineca nel campo della Virtual Archaeology. In CORALINI A. AND SCAGLIARINI CORLÁITA D. (eds.) *Ut Natura Ars. Virtual Reality e archeologia. Atti della giornata di studi, Bologna 22 apr 2002*, University Press Bologna, 2007, 81-89

[Ron09] RONCHI A.: ECulture. Cultural Content in the Digital Age. Springer, 2000