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ACCESSING INFORMATION NAVIGATING IN A 3D INTERACTIVE ENVIRONMENT

PhD Program in European Doctorate in Technology and Management of Cultural Heritage

XX Cycle

By

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2008

Contents

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Laura is an architect and PhD student in Technology and Management of Cultural Heritage (TMCH) by IMT Lucca Institute for Advanced Studies (Institutions Markets Technologies) and she will discuss it in European Doctorate.

Her work's goal is the development of new method to access geo-referenced information through the interactive navigation of a synthetic 3D model that is called ISEE.

She worked in two main groups of research during the university of architecture in Florence, where she graduated (with the maximum mark, 110/110 cum laude). She got through the Architect State Examination

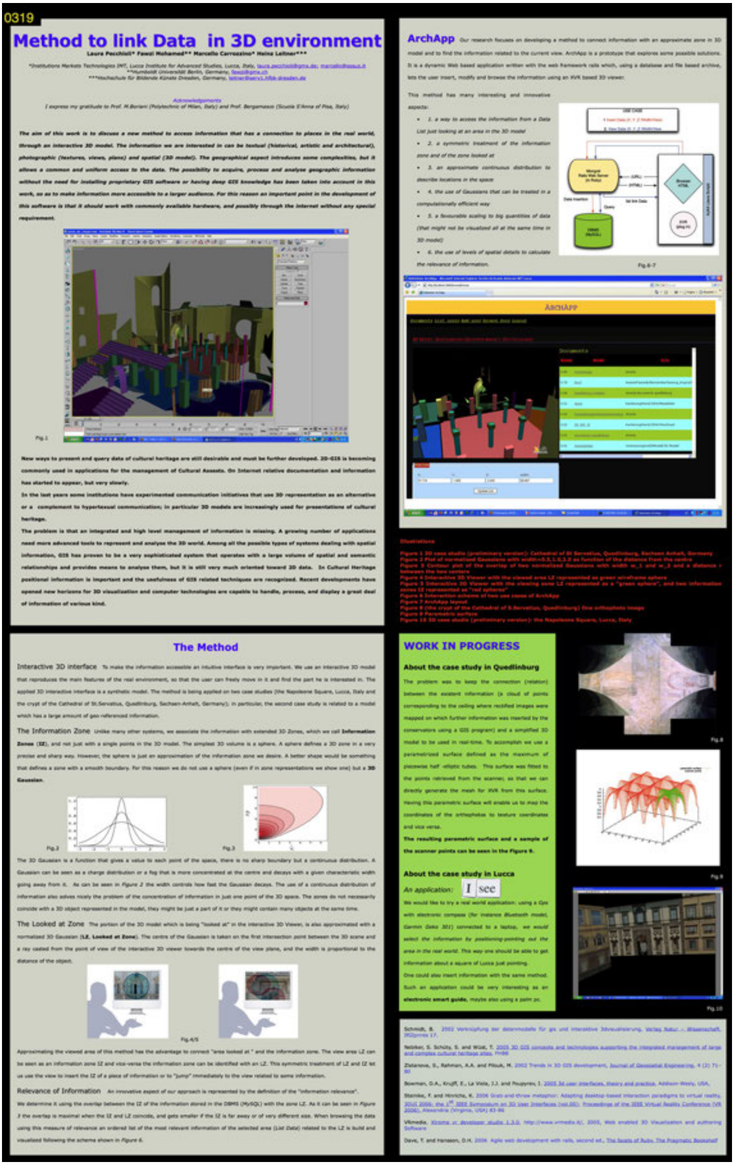

Figure 1: Poster CAA2007

Executive Summary

Access to information enables knowledge to be shared among people; it is therefore becoming increasingly important. Cultural heritage is an interdisciplinary field that draws together several different professions. Information is gained from different sources and in varying formats. Furthermore, the relationship between the conservation managers, who are often unfamiliar with current documentation techniques, and the providers of the information, who tend to be highly technical practitioners without expertise in cultural heritage, is not easy to handle.

The result of this work is one method called ISEE. This method allows spatial information to be accessed through the interactive navigation of a synthetic 3D model, reproducing the main features of a corresponding real environment. The user can get the pieces of information more relevant where he is looking at it. The system can be used with standard Web browsers, allowing access to a wider audience without any special requirements.

The system has been applied to selected case studies related both to outdoor and indoor environments, proving potentially to be also an interesting prototype as a smart guide with the use of augmented reality technologies.

Chapter 1

Introduction

1.1 Motivation and background

As the whole field of preserving, documenting and studying our cultural heritage is interdisciplinary, the way in which information is managed is not homogenous. Information may come from various fields (artistic, historical, architectural, geographic, etc.). Its sources can be historical documents or may be the result of recent analyses. There are different kinds of possible data: texts, images, sounds, films, multimedia or interactive documents. In latest years there is a significant trend towards the massive digitisation of this data, as this allows more efficient and reliable storage and management processes.

A significant part of digital information on cultural heritage sites and artifacts is based on pre-existing works that have been subsequently digitally reproduced. However, nowadays new information is often produced directly in a digital format, and very often it exists only in this form (multimedia productions, scientific databases,etc.).

Unfortunately, having the information in a digital format is not enough. There are many kinds of textual, geometric or geographical information, images (ortho-photos, normal photos and planes), or 3D information, which exist in very different formats. This raises non-trivial issues on the long-term preservation of this data, along with issues on their future understand-ability and handling.

Storage, organisation, and retrieval of such information is challenging and commonly not very well structured. Very often the only unify-

Chapter 2

Previous work

The core of the ISEE method is the information selection and ranking. The goal of this section is to give an overview of the existing work connected to the direct subject matter of the thesis. As the thesis is quite interdisciplinary there are several fields to cover and it's necessary to introduce a short description about them.

First in Section 2.1 we discuss information management, CityGML and CIDOC CRM providing a common and extensible semantic framework, the problem of future accessibility, the importance of knowing the origin of data and copyright/privacy issues, because these are important for any archival system.

Then we look Section 2.2 at information visualisation with the visualisation of spatial information and in particular with Geographical Information System (GIS) as main objectives. Although the visualisation of spatially related information is one of the topics of our method (ISEE). ISEE does not aim at becoming a GIS system.

The following Section 2.3 is about interactive 3D environments and applications. Virtual Reality and 3D user interfaces are the topic of that section.

In the Section 2.4 we talk about 2D and 3D GIS applications and the importance of considering a context when we dealing with a 3D space. Then we discuss 3D geovirtual environments and Web GIS.

Then, Section 2.5, the Web is discussed, and in particular GIS and 3D applications using the Web in a short report. Furthermore, we provide an introduction its standards (Web 3D Consortium). We also take a look at 3D visualisation and the powerful XVR (plug-in) toolkit that is used in this work.

Figure 6: An example of Post processing

2.2.3 GeoDataspatial information

Any information that defines, or is associated with, a specific location relative to the Earth's surface or a spatial address, is *geospatial information*.

Spatial information is information geographically referenced on the Earth's surface. In particular, spatial information identifies the geographic location of natural or constructed features and boundaries on the Earth, including both GIS [11] and CAD data [12]. In particular it may be divided into two categories:

The advent of geospatial data infrastructures has allowed geospatial information to be accessed, but this access always requires complex procedures. There are 2D geodata as topographic and thematic maps, and 3D geodata as e.g. 3D terrain models, 3D building and vegetation models.

2.2.3.1 GeoDatabase

A geodatabase is the common data storage and management framework for software involved in the analysis of geodata. A geodatabase can sup-

[11]Nowadays Geographic or Geospatial Information System (GIS) are used to handle this data. GIS integrates hardware, software, and data for capturing, managing, analysing, and displaying all forms of geographically referenced information. Geographic Information System uses vision to communicate information to the user.

[12]Computer-Aided Design. A CAD system is a combination of hardware and software that enables engineers and architects to design everything

Chapter 3

The ISEE approach

3.1 Motivation

In the Cultural Heritage field, one has to deal with information from different sources and in different formats; often it is very easy to produce a lot of data in a short amount of time. In the case studies presented in this thesis (the Piazza Napoleone in Lucca, Italy/the crypt in St.Servatius in Quedlinburg, Saxony Anhalt, Germany/MuS's a virtual museum), we deal with information available as images, ortho-photos, texts, and also in GIS format. In particular, the second case study is related to a model which has a large amount of pre-existing georeferenced information.

Objects in Cultural Heritage often have a strong 3D component, and cannot be easily represented with a 2D-map.

The use of 3D models is more intuitive and more easily grasped than abstract maps(BKLVP05). The 3D representation allows a closer adherence to the real world (and the use of real co-ordinates), and respects the spatial relationships that are present among the various parts, whereas a projection deforms (or even looses) them. Also for urban spaces, in which 2D maps are well established, the use of 3D views can help a user to identify landmarks and is generally seen as a good and fun addition to 2D maps (CGSL03; Kol04; RTV01).

As mentioned in the Chapter 1, the internet has changed the way we organise data, but an integrated management method for cultural heritage ICT applications is still not available. GIS methods are being increasingly used, but often the 2D interaction is limiting for these applications

Chapter 4

Implementation

The core of the ISEE method is to connect information with an approximated zone in a 3D model, in order to find the information most closely related to the current view using the spatial relevance described in the previous chapter. To actually implement the idea in a working and usable program there are many other issues that have to be considered. This chapter describes them, starting from the interface issues, then with technical implementation details and finally with the results of the usability test performed.

4.1 Interface

4.1.1 Interactive 3D Interface in ISEE

The graphical user interface of ISEE has been designed in order to be simple, intuitive and user-friendly. The interaction is based on the traditional WIMP interface (Windows, Icons, Menu, Pointers), with the notable feature of a window containing a 3D view of the virtual model representing the information environment.

Its basic structure (3D Model with small 2D map and list of relevant information) was decided quite early, as can be seen from the mockups in the appendix. The 3D model is interactive and can be freely navigated; there is also a 2D map view which can be used to move around and identify the surroundings. The spatial context of the query is interactively definable on the 3D model. The idea is to dynamically produce, while

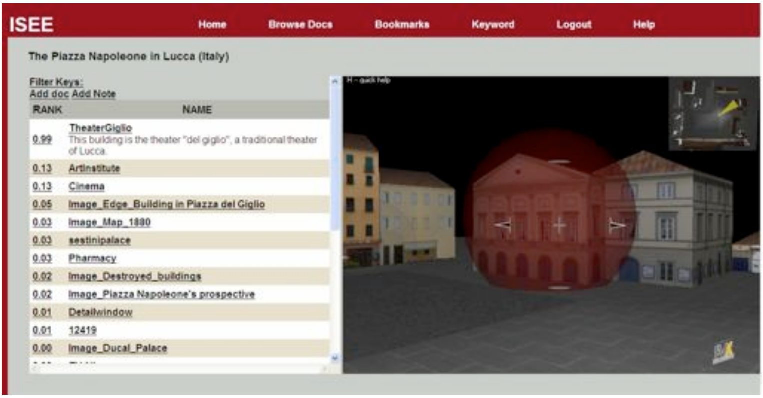

Figure 28: The browsing interface in the Lucca case, cross-hair and an IZ are visible

the user is moving, a list of the information relevant for the current View Zone. When a data set is selected, related extra information is shown below: if the user double clicks it, a Web browser window with meta-information and access to the original data is provided.

In order to visualize and interactively navigate the model on the Web, we used the XVR technology (CTBB05), jointly developed by PERCRO Scuola Superiore Sant'Anna in Pisa (Italy) and VRMedia s.r.l.. The 3D model is downloaded on the user client as soon as the user accesses the Web page. As soon as the download is finished, a first list of information automatically appears, presenting on the top the data most relevant for the zone the user is currently looking at.

ISEE allows the following operations to be performed:

- to query and search
- to visualize and read
- to modify and show
- to share and update
- to compare and have an high level overview of the data present
- to add new data.

Chapter 5

The case studies

The prototypes developed in this work represent an Web application where the user can explore in intuitive way a model and to discover the information linked to it.

The case studies analysed have related both to outdoor and indoor environments, in particular for the case study of the Piazza Napoleone, along with the internet we tested a real world outdoor application using a GPS Compass (Vector CSI Wireless), providing 2D heading and positioning data, connected to a laptop (Pentium IBM ThinkPad T42), that gave access to architectural and historical information about the urban development of the square.

The case studies have been:

- the Piazza Napoleone in Lucca (Italy)
- the crypt of the Cathedral of St.Servatius in Quedlinburg, Saxony-Anhalt (Germany)
- MuS's (a 3D virtual environment)

The model in all the case studies is a 3D interactive synthetic environment. The usage of a synthetic model allows the information to the zones to be linked more effectively and to have a good and quick interaction. It is possible to have interactive high-level models, even loaded through the internet, but this is an active research topic that is not the focus of this thesis.

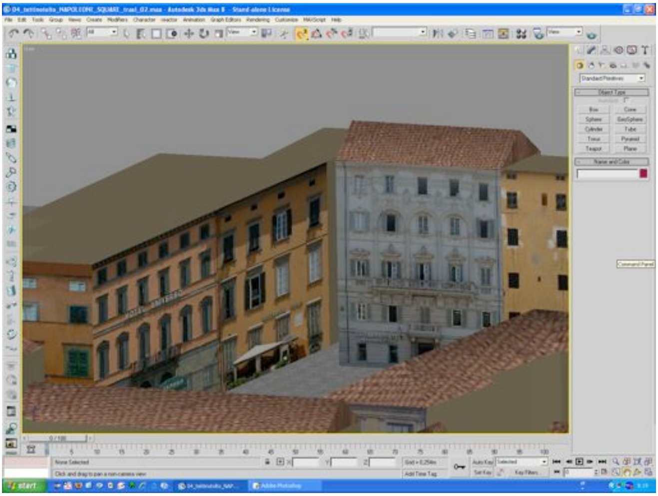

Figure 43: The creation of the model of the square

The two central meridians of these regions are the $9\,\mathrm{deg}$ and $15\,\mathrm{deg}$ with respect to the meridian in Greenwich. In the 3D model we used a different false Northing and Easting than the *ROMA40 Gauss-Boaga*, so that the false origin would be in the Piazza Napoleone.

This is necessary because some programs had problems with coordinates having the "large" numbers of the Gauss-Boaga coordinates: the accuracy of a single precision number corresponded to tens of centimeters and rounding errors where visible. After all these preparations a textured 3D model was created using our photos.

Piazza Napoleone proves a good case study potentially to be also an interesting prototype as a smart guide with the use of augmented reality technologies.

5.1.3 Data

The collecting of the information for the Piazza Napoleone has not been the focus of this work, thus it might be incomplete, and not always of perfect quality. What we were interested in is how to visualise informa-

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Chapter 6

Conclusions

6.1 Discussion

It is now possible to provide an answer to the key questions formulated in section 1.1.1, in terms of the research presented in this thesis:

How to provide a "unified" management methodology to information, often deeply dishomogeneous and non-uniform, like that involved in Cultural Heritage ICT applications?

The ISEE methodology proposes a way to address this issue: it shares with GIS systems the basic concept of referencing data using spatial information, but extends this concept to 3D environments, as most of cultural assets (like sculptures, architectures, sites and so on)are actually not easily representable in 2D. The 3D model of the asset represent the unifying element around which data are connected

How to provide an efficient way to deal with big amounts of information often contained in a small physical space (high density of information)?

The ISEE basic idea is to allow retrieving information by just "looking around" in a 3D environment, as moving and looking at the world is the main modality we use to gather information from it. As the amount of information we retrieve in this way can be sometimes overwhelming, ISEE shows only the "pieces of information" relevant for the current *view*, i.e.

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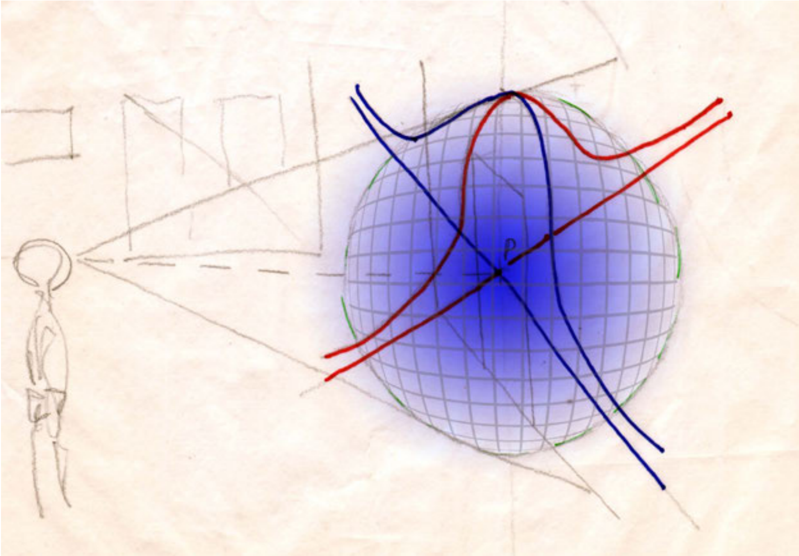

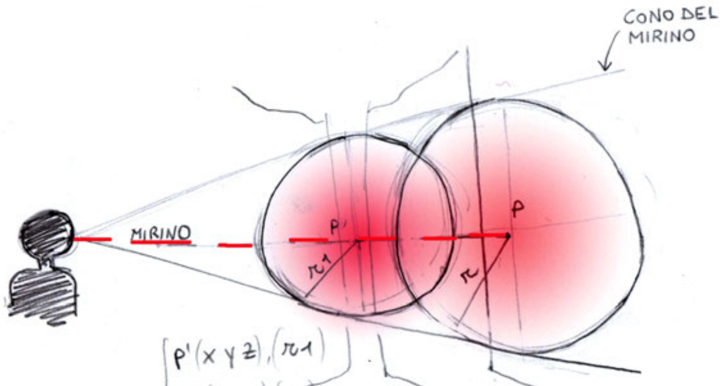

In questa immagine si vedono due casi insieme di due zone,:

il primo rappresenta un caso in cui una zona è più vicina per la vicinanza all'user (albero) ed è più concentrata. Il secondo invece rappresenta il caso in cui una zona è più lontana e più diffusa (edificio).

Universität Heidelberg
Best Student Presentation Award - SCCH09
Scientific Computing & Cultural Heritage Konferenz

ISEE: retrieve information in Cultural Heritage navigating in 3D environment

Laura Pecchioli, Fawzi Mohamed and Marcello Carrozzino

Abstract Cultural Heritage is an interdisciplinary field and the information is gained from different sources and in varying formats. Moreover, the objects often have a strong 3D component, and cannot be easily represented with conventional data management frameworks like Geographic Information System (GIS). The use of a 3D framework may allow a closer adherence to the real world, as it respects the spatial relationships among various parts. Starting from these important points, we developed a method called ISEE ("I see ")[1]. This method allows spatial information to be accessed through the interactive navigation of a synthetic 3D model, reproducing the main features of a corresponding real environment. The user can get the pieces of information more relevant where he/she is looking at it. The system can be used with standard Web browsers, allowing access to a wider audience without any special requirements[18]. The system has been applied to selected case studies related both to outdoor and indoor environments, proving potentially to be also an interesting prototype as a smart guide. [2]

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[1] The result of a European Doctor in Technology and Management in Cultural Heritage, "Accessing Information Navigating in a 3D Interactive Environment"

[2] The case studies analysed have been the following: the Piazza Napoleone in Lucca, (Italy), the cript of St.Servatius in Quedlinburg, (Sachsen Anhalt- Germany) and a virtual museum, MuS's. In the last version of interface we added: the archaeological site of the city of Baalbek (Lebanon) of a Ph.D student of the Technische Universität Berlin, and a synthetic 3D model of the center of the city of Berlin (provided for research by the Senatsverwaltung für Stadtentwicklung Berlin).

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ARTICLE IN PRESS

Journal of Cultural Heritage xxx (2011) xxx–xxx

Available online at
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Original article

ISEE: Information access through the navigation of a 3D interactive environment

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ARTICLE INFO

Article history:
Received 30 June 2009
Accepted 26 November 2010
Available online xxx

Keywords:
Interactive 3D interface
Virtual reality
Augmented reality
Normalized 3D Gaussian
Spatial relevance
Cultural heritage data

ABSTRACT

Managing heterogeneous information related to Cultural Heritage sites and artifacts is still a complex task. In latest years, there has been a significant trend towards the massive digitization of this data, as this allows more efficient and reliable storage and management processes. Furthermore, the relationship between conservation managers, who are often unfamiliar with current documentation techniques, and information providers, who tend to be highly technical practitioners without expertise in cultural heritage, is not easy to handle. Moreover, in Cultural Heritage objects often have a strong 3D component, and cannot be easily represented with conventional data management frameworks like Geographic Information System (GIS). The use of a 3D framework may allow a closer adherence to the real world, as it respects the spatial relationships among various parts. A novel method to access spatial information through the interactive navigation of a synthetic 3D model, reproducing the main features of a corresponding real environment, is proposed in this paper. The result of this work is a system called ISEE. An innovative aspect of the ISEE approach is represented by our definition of spatial relevance of information. The information is ranked with a novel measure of relevance that depends on the position/orientation in the 3D space, and allows for an intuitive interface. The basic idea of ISEE is to allow retrieving information by just looking around in a 3D environment, as moving and looking at the world is the main modality we use to gather information from it. Users explore in intuitive way a 3D environment and access the related information, kept in its spatial context. Information are accessed through "extended zones", i.e. portions of the 3D environment not having direct reference to specific elements, rather to the distribution of information and to the current user location. The use of extended zones gives to the proposed ranking algorithm a superior performance than rankings methods based on distance. Indeed the ISEE ranking matches the intuitive expectation of the users, as was verified with a formal usability test. The system has been applied to case studies related both to outdoor and indoor environments, showing its potential also as a smart guide with the use of augmented reality technologies. In order to enable access to a larger audience, sample applications using this method are based on Web technologies and do not require special training to be used. At the end of the paper are presented the results of an evaluation test, which provided useful suggestion to improve the system usability and performances.

1. Research aims

The goal of this research is to develop a method to store and access cultural heritage related information. Authoring and retrieval of information should be made as simple as possible in order to be used by professionals from different fields and by the general public. Very often this kind of information have a strong 3D component and cannot be easily handled by means of conventional management systems. In order to comply with this requirement and to enhance the user involvement, we propose a method based on the navigation of an interactive 3D environment. The design of a 3D interactive interface [1] suitable for such a purpose is not a trivial task. Current selection methods, even the most established ones, have several drawbacks (tricky management of hidden or overlapping objects, sensitivity to the distance, etc.). In order to overcome these issues and to keep the navigation simple, the system should allow an intuitive interaction, where information

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doi:10.1016/j.culher.2010.11.001

2010 A. Alamouri, L. Pecchioli.ISEE: retrieving information navigating in the historical Baalbek. In: ISPRS Proceedings of the 5th 3D GeoInfo Conference, 3-4 November, Berlin, Germany

RETRIEVING INFORMATION THROUGH NAVIGATING IN HISTORICAL BAALBEK

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KEY WORDS: Cultural heritage data, 3D city model, accessibility Web, 3D interface, spatial relevance.

ABSTRACT:

In Cultural Heritage the information is gained from different sources and in varying formats, so it is not easy to deal with a uniform treatment of heterogeneous data. The problem arising therefore is: how to provide a unified management methodology of the information and to enable an access for this kind of information to large audiences. In this article we used a new method called ISEE ("I see" the origin of the name) to access spatial information through the interactive navigation of a synthetic 3D model, reproducing the main features of a corresponding real environment. In this method, the information is ranked with a novel measurement of the relevance that depends on the position/orientation in the 3D space, and allows an intuitive interaction. To give access to a larger audience, ISEE is available on the internet using modern web browsers without any special requirements. The system has been proved in different study cases related to outdoor and indoor environments. In this context, ISEE has been applied to the case study of 3D city model of historical Baalbek in Lebanon which was created based on the photogrammetric evaluation of Baalbek's graphical materials. The result of this work is that the users, from different branches (like archaeology, architecture, etc.) can obtain and share data about this city, as required for their own researches and applications.

1. INTRODUCTION

Cultural Heritage is an interdisciplinary field and the way, in which information is managed, is not homogenous. Some projects try to create a framework to visualise and query archival resources, and improve information sharing for an easier access to information. Moreover the objects have often a strong 3D component and can not be easily represented with a 2D map (Pieraccini et al., 2001).

Today the 3D visualization has a variety of applications and technologies which enables us to render a detailed simulation of urban systems also of antique settlements (Kulitz et al., 2006; Mine, 1995). 3D visualization simulates spatial reality, allowing the viewers to recognize what they see in the real world, but the transition between different realities is not easy and does not always satisfy expectations. In addition an integrated and high level management of information is also missing. When dealing with Cultural Heritage assets, the acquisition of information in a three-dimensional form is still not always an easy task. On the other hand, huge number of applications requires more advanced tools for representing and analyzing the 3D environment (Bowman, 2005).

The field of the Cultural Heritage is greatly interested in using the emerging and available new digital techniques and technologies offered by the Geomatics. In particular, in archaeology the usage of Geographic Information Systems (GIS) techniques and of photogrammetry is quite common.

In this article, we present the result of an interdisciplinary work to visualize the results of investigations and experiments of an archaeological-historical context as Baalbek in Lebanon, using an innovative method called ISEE. It has been applied successfully in previous case studies in both outdoor and indoor environments (Pecchioli et al., 2007).

Using sight, we naturally focus on something and we can try to use this as "an easy language", which people can use to query, insert and share the information (thus the name "I see"). The method provides an intuitive interaction and allows the user to access the information through navigating in a 3D environment. We chose to link the information to 3D zones in the space. These 3D zones have to be defined interactively, and with minimal user interaction (just by looking), therefore we have chosen to keep them geometrically very simple (like spheres). Thus the zone, the user is interested in, most likely does not perfectly coincide with the sphere, and using a smooth boundary reflects the approximate nature of the zone defined. We use a 3D Gaussian, which has maximum in the center and a normal distributed decrease away from it, to define these approximated zones.

2. HISTORY OF BAALBEK

Baalbek is situated on the northern of the Beqaa-Plain/Lebanon, which was settled in the beginning of 3rd millennium BC (Van Ess, 1998). This city is inscribed as an important urban heritage site since 1984. It is famous and tourist attraction due to the 5000 years of the history of the city as well as the Roman constructions such as: the temples of Jupiter, Venus and Bacchus. These temples and the old preserved dwellings validate the historic importance of this city.

The sanctuary of Baalbek has been designed in a new form and built as a monumental work which was not known before. Through the (4th - 7th centuries) Baalbek had gotten more Christain churches which could displace, but slowly in the old cults. In the Islamic era (in 635 AD) and in the (12th-14th centuries) the site of temples had been converted into a great fort.

In the end, there are historical photos of Baalbek which are considered the main source about the historic data. These photos have different problems (due to their poor properties such as: different cameras used and different image scales, etc.). Thus, these problems are the main reasons that the data acquisition and accessibility based on the oriented model of the photos are not easy task.

3. BAALBEK'S 3D CITY GML-MODEL

The modelling of 3D data extracted based on the oriented historical images of Baalbek is considered an important task, because it enables to represent Baalbek's data as well as to document the historic city and its remains as it looked like. In the context of a city modelling, standards of CityGML (City Geography Markup Language) will be implemented.

CityGML is defined as an open data model used for representation and exchange of virtual 3D city models. It is an international standard for the semantic and geometric representation of 3D city and landscape models (Kolbe, 2009). The modelling based on CityGML supports different four aspects of virtual 3D city model: semantic, geometry, topology and appearance. In this context, objects of reality can be represented in up to five well defined levels of detail (from LOD0 to LOD4) where the higher LOD the higher accuracy and structural complexity. Those 5 LODs were based on previous work related to different research groups on the usage of levels of detail in the 3D city modelling (Köninger & Bartel, 1998, Coors & Flick, 1998, Schilcher et. al., 1999).

The coarsest level LOD0 is essentially a 2.5D DTM (Fig.1.a). In contrast, the LOD1 is the well-known blocks model of the buildings with flat roofs structures. In this LOD, the geometry of a building is represented a prismatic object with a flat top (cf. Fig.1.b). In other words: geometry of a building can be either represented with gml:SolidType as a volumetric object or the exterior surface of the interested building is represented with gml:MultiSurfaceType. Buildings are represented in LOD1 in a simple form i.e., extensions to buildings such as balconies need to be disregarded when creating of the LOD1 model. In addition, any curvatures in the geometry of walls and roof slab, these should be eliminated. To preserve such simplification of objects, different entities can be implemented such as: IFCWall entities (Industry Foundation Classes entities) or the usage of bounding box representation of elements (Kolbe, 2009, Isikdag & Zlatanova, 2009).

On one hand LOD2 has more details about the roofs' structures. In addition, exterior surfaces of a building can be represented in higher details (cf. Fig.1.c). The main differences between LOD1 and LOD2 - from geometrical aspect - are as following (Kolbe, 2009, Isikdag & Zlatanova, 2009):

- In LOD2 outer walls of a building can be represented using multiple faces, but in LOD1 just only a single face for each wall.
- The curve geometry of elements can be represented within the model structure.
- Outer building installations such as chimneys, balconies, dormers, etc. can also modelled in the LOD2 of CityGML model. In this context, these installations can be represented within the BuildingInstallations class as gml:Geometry.

On the other hand different parts of the outer façade of the building can be represented starting from LOD2 with different classes of CityGML. These classes are aggregated under "_BoundarySurface" class and therefore can be used to explicitly differentiate Roof Surfaces, Wall Surface, Ground Surface and Closure Surface.

LOD3 of CityGML includes openings associated with the outer façade of the building such as window and doors (Fig.1.d). Here, these openings are represented with Door and Window classes which are defined as sub-classes of the abstract class Opening. The class Window is used to represent the windows inside and the outer façade of the building. Similarly for the class Door, this is used to model the doors that are between the adjacent spaces and located at the outer façade of the building (Isikdag & Zlatanova, 2009).

The last LOD of CityGML is LOD4 which represents interior structures of objects. The main classes of CityGML used to realize the interior structure of a building are Room and IntBuildingInstallation. The class Room presents the semantic object for modelling of the space inside the building. It should be closed (using for e.g. ClosureSurface) and can be represented (from geometrical view) by gml:Solid. In addition, semantic data related to the room can be preserved within the classes aggregated under _BoundarySurface class (Fig.1.e).

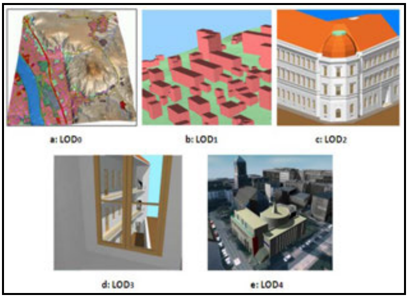

Figure 1: The five levels of detail (LODs) defined by CityGML. LODs of CityGML (LOD0 to LOD4) are depicted in a, b, c, d and e, respectively (Source: IGG-Uni Bonn)

In the case study of Baalbek, the 3D model of this city based on its historical images has been created (Alamouri & Gründig, 2009). The modelling of the available data is geometrically represented in two Levels of Detail (LOD1 and LOD2). Illustrations of both LODs are shown in the Figures (2.a & 2.b).

Figure (2.a): Baalbek's model in LOD1
(Source: Alamouri & Kolbe, 2009)

ISEE-Using an innovative method to archive and share information

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ABSTRACT

Today the new technology can improve the visualization and the accessibility to information. In particular the digital archives, web applications and virtual reconstructions can help the preservation in the various fields of the Cultural Heritage. The usage of 3D environments is not an easy task, but it improves the understanding of the object or a context. Especially via Web there aren't many cases of web applications with 3D models connected to data and accessibile in real time.
Moreover the communication between who produces the information and who should develop softwares managing data, is often lacking and represents an important issue.
In this contribute we present an innovative method called ISEE, that allows the user to retrieve information using the simple navigation in the model. It represents a development of a tool in the Cultural Heritage born from an interdisciplinary collaboration. The system can be used by a common user or a professional figure, because it doesn't have any special requirements using the modern web browsers through internet. The system has been applied to selected case studies relative both to outdoor and indoor environments, proving potentially to be also an interesting prototype as a smart guide.

KEY-WORD: 3D visualization, relevant information, 3D Gaussian, virtual reality, preventive conservation, web-based visualization.

Introduction

The use of the new technologies in the Cultural Heritage has changed the perception and interaction with the object that we analyse, introducing a new issue: the communication between who produces and archives the information, and who develops softwares to manage and guarantee a future accessibility. The treatment of the third dimension also in the diagnostic techniques has contributed to a new approach in the visualization and archival of information in the field of conservation (Brumana et al., 2005).
Today the Virtual Reality (VR) and the Augmented Reality (AR) belong to the language of the Cultural Heritage, together with the commonly used terms like stratigraphy, laser scanner and thermography. There is an increasing interest in developing 3D reconstructions of towns, monuments, archaeological sites during different historical eras and before and after an intervention of preservation (Manferdini&Remondino, 2010). The virtual reconstruction can record the current state of the manufact and integrate the information lost like an approach of preventive conservation; its use can be very useful to create audiovisual presentations and interactive applications in museums and cultural foundations too. Ideally, a visitor should be able to visit a museum and receive in real time contextual information about the object of his/her attention. Interactive smart guides could also allow people to contribute to the general knowledge, following the paradigm of Web 2.0, by creating content and inserting new information about their experiences on events, objects or places. This should happen not only in museums, but in every place, even outdoor, so as to transform a city into an open-air museum (Mine, 1995).
In particular in situations as in the catacombs with micro-climatic problems, where the accessibility must be controlled (Pecchioli&Mazzei, 2011a) a 3D visualization can be very useful to preserve and guarantee the visibility of the monument.
Also in the preservation of the mural paintings, the technology is becoming persuasive in the digital acquisition of surfaces, mosaics and paintings, using 3D both for the reconstruction of models and in the communication of the information via Internet (Schmid, 2000).

DAS DURCH ISEE KREIERTE ZAFAR VIRTUAL MUSEUM (ZVM), JEMEN

Forschungsgeschichte

Über 250 Jahre (270–523 n.Chr.) beherrschten die Himjaren mit ihren Alliierten das Gros der Arabischen Halbinsel, drei Viertel so groß wie Westeuropa. In ihrer Hauptstadt Zafar treffen wir auf eine Schlüsselstelle der Weltgeschichte, kurz vor dem Übergang zum Islam.

Heute ist die ehemalige Hauptstadt mit einer Bevölkerung von 450 ein armes Dorf im jemenitischen Hochland. Von seinem früheren Ruhm ist kaum noch was vorhanden. Paolo Costa schreibt, „nach dem Sommer 1972 führte ich eine erste archäologische Erkundung um Zafar durch. […] Etwa 902 fragmentarische reliefierte Steine […] sind in zwei Häusern im Dorf vorhanden“; 1975 schrieb er, dass das Ortsmuseum noch in Planung sei [1]. 1978 nahm Raymond Tindel die Arbeit in Zafar auf [2]: 674 Artefakte hat er zusammen getragen, die für das Museum inventarisiert werden sollten [3]. Die Raubgrabungen und Sammeltätigkeit im Dorf erweckten die Aufmerksamkeit des neuen Direktors des Antikendientes, Qaḍi Ismʿāil bin ʿAlī al-Akwaʿ, der 1978 die ersten Baumaßnahmen anordnete. Der Präsident der Volksrepublik des Jemen, ʿIbrahim al-Ḥamdi, besuchte das Dorf und verlieh dem Museumsprojekt sein Gewicht. Wenige Jahre später nahm das Museum seine endgültige Form an, blieb aber vor 2002 weitgehend leer.

2002 unterstütze das Zayed Centre for Coordination and Follow-up in Abu Dhabi (2003 geschlossen) die Autoren mit 12000 US$; damit konnten zehn zweisprachige Poster, Saalzettel sowie Flugtickets und Aufsichtspersonal finanziert werden. Die *General Organisation for Archaeology and Museums* (GOAM) hatte das Gebäudedach erneuert und den gesamten Bau renoviert. Die drei Ausstellungsräume, zusammen 92 m^2, sind Inschriften, bildender Kunst und Archäologie gewidmet. Dazu gibt es ein Magazin mit 18 m2, außerdem einen kleinen Raum für die Lagerung der Werkzeuge und ein kleines Büro, in dem die Grabungsmannschaft gearbeitet hatte. Eine 4 m hohe Mauer umschließt das Museum.

Zafar/Yemen Virtual Museum

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3D visualisation models have proven themselves in all fields, and in recent years a variety of applications have appeared in archaeology. The rapid development of digital technology enables the rendering of all manner of objects and contexts in cultural heritage. 3D visualisation allows a close adherence to the real world, as it builds on the spatial relationships among various parts. Interactive technology makes information more accessible and vivid, thus enhancing user experience.

Our contribution presents the web application of a virtual museum in Zafar, in the Highlands of the Yemen. This we installed in 2002. The site's inaccessibility and the political unrest prohibit visits by foreign tourists and scholars. The project of the Zafar Virtual Museum communicates knowledge on important and little-known Himyarite artefacts exhibited.

View of the Virtual Museum

The Zafar Virtual Museum application comprises an interdisciplinary effort realised with limited resources. The 3D model was not conceived from the beginning as a project in the prime sense, but rather was assembled from images and texts created for other purposes. Great accuracy in the

CHNT - 2012

ISEE sharing - tool in Cultural Heritage. The Museum of the sculptures in the Basilica of St. Silvestro at the Catacombs of Priscilla

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Keywords: 3-5
accessibility Web, 3D interface, Cultural Heritage Data,

Ideas of the project/main objective

The approach has been to maintain the pieces in their original context of the basilica and give better access to the monument through an architectural project and in particular a web-application based on a method called ISEE (the name of the method that means “I see”). Our interdisciplinary collaboration is a contribute to develop an innovative sharing tool for the accessing, managing and sharing the information in its context.

1 Methodology/Approach: How were the objectives reached? Which method/s was/were used?

2 Results: What is/are the result/s of the work?

3 Innovations: What is new and significant about your ideas, methods, and/or results?

200-300 words

The web application is based on a software, called ISEE, that presents an intuitive and user-friendly interaction for accessing, inserting and modifying information in a 3D environment. As it is based on the simple action of navigating the 3D space allows an intuitive interaction and can be suitable to all categories of users. New pieces of information can be inserted in the same way in which they are queried, just by looking in 3D. The study of the sarcophagus is a particular field of research in archaeology, and not easily accessible everywhere. The numerous fragments allow not to introduce many information in the exhibition of the sculptures. The web application will be unable to connect each fragment to the existent database in detail and using Internet. Moreover the virtual visit can solve the climatic problem for the underlying environment of the catacombs and allows the relative accessibility. To visualise and interactively navigate 3D models on the web, we use the Unity 3D

La catacomba di Santa Tecla e il metodo I-SEE

Spazio virtuale 3D per un linguaggio interdisciplinare comune

Laura Pecchioli, Barbara Mazzei

Introduzione

Documentare, condividere e diffondere i risultati di un intervento di restauro è un'esigenza fondamentale che nasce dalla formulazione del principio di rispetto per l'integrità dell'opera d'arte. Tale fondamento si trova chiaramente espresso e ribadito in tutta la serie di documenti normativi riguardanti le attività di conservazione e restauro, che dal 1931 con la Carta del Restauro di Atene hanno avuto l'intento di sancire e unificare le procedure relative alla salvaguardia, alla tutela e alla conservazione dei Beni Culturali[1].

Il sempre più ampio apporto all'attività di conservazione di un Bene da parte di discipline afferenti a diversificati ambiti scientifici ha ulteriormente stimolato la necessità di ricercare un linguaggio comune, univoco e condivisibile tra i molteplici "attori", necessità che si è tradotta in una vera e propria attività di normazione. A tale scopo nel 1977 venne fondata la Commissione NorMaL, confluita nel 1996 nella Commissione Beni Culturali UNI/NorMaL[2], per una maggiore validazione normativa delle precedenti "raccomandazioni". Dal 2006 diventa a carattere europeo con l'istituzione di una Commissione Tecnica dell'European Commitee for Standardization, CEN/346 Conservation of Cultural Property[3].

Ancora a livello internazionale, l'International Committee for Documentation dell'International Council of Museum (ICOM-CIDOC) ha sviluppato un modello concettuale di riferimento (CRM), che fornisce definizioni e struttura formale per la descrizione degli oggetti afferenti al patrimonio culturale, sempre con lo scopo di creare un quadro comune e una visione condivisa e mediata tra le differenti fonti d'informazione. Si tratta di un modello facilmente estensibile, che potrà agevolmente adattarsi agli inevitabili progressi futuri, e diventato ufficialmente uno standard ISO 21 127:200[4] dal 2006.

Parallelamente a tali attività, si registra un costante progresso tecnologico finalizzato alla restituzione grafica e virtuale degli oggetti nel loro contesto, innovazione quanto mai proficua in vista di una sempre più efficace attività di documentazione. L'evoluzione tecnologica si presenta però con tempi diversi rispetto agli aggiornamenti normativi.

Nel 2003 l'ICOMOS Principles for the Preservation and Conservation/Restoration of Wall Paintings si esprime in merito solo con una generica e parziale apertura, concedendo che i "tradizionali metodi di documentazione scritta e grafica possono essere integrati da metodi digitali"[5].

L'interdisciplinarità e la gestione delle relative informazioni eterogenee rappresentano tuttora, visto l'apporto continuo di metodiche innovative, un importante tema di dibattito nel settore dei Beni Culturali. L'archiviazione digitalizzata dovrebbe garantire una leggibilità futura dell'informazione, e l'adozione di nuove tecnologie lo scambio tra le diverse discipline coinvolte. Digitalizzare però non assicura nessuno di questi due aspetti, ma richiede al contrario all'utente di possedere una conoscenza informatica. In particolar modo, la mancanza di un linguaggio comune tra chi opera direttamente sul manufatto, come i restauratori, e chi sviluppa per questi ultimi programmi che dovrebbero facilitare il lavoro, ostacola spesso lo sviluppo di strumenti realmente efficaci e di lunga durata. Un importante ruolo in questo senso sta avendo la Commissione ICOMOS/ISPRS per la Documentazione nei Beni Culturali (CIPA Heritage Documentation). Tra il 1995 ed il 1999 ha condotto una serie di workshop per capire questa incompatibilità, e supporta il progetto Recording, Documentation, and Information Management (RecorDIM) Initiative con lo scopo di individuare queste problematiche[6].

Un altro contributo importante è stato quello prodotto da GRADOC, Graphic Documentation

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VSMM - 2012

Browsing in the Virtual Museum of the Sarcophagi in the Basilica of St. Silvestro at the Catacombs of Priscilla in Rome

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***Abstract*—This paper outlines a program (ISEE) to visualise interactive 3D environments and access information through the Web. ISEE had been prototyped as content management tool with Internet Explorer since 2008 and currently supports the major browsers. Its database of information is stored in MySQL. The basic idea of the software is to enable information retrieval by simply looking inside a 3D environment, since moving and looking in the real world are basic interactions, which all viewers use. It ranks the relevant information by means of its position/orientation of the viewer in 3D space. The ranking algorithm that we developed matches the intuitive expectation of users as verified by means of formal usability tests. We present its application in the project in progress for the Museum of the sculpture in the Basilica of St. Silvestro at the Catacombs of Priscilla in Rome, where the user will be able to retrieve information through the virtual visit and using QR-code in situ for each fragment of sarcophagi. An important aspect with internet usage is the optimisation of the 3D model. This has been achieved creating a low poly 3D mesh with the application of normal and displacement maps generated with a baking process of the high poly 3D model. In this way we have optimized for the Web and the interactive use. To reduce the chromatic aberration a massive photographic campaign was used to texturize the 3D model through a camera matching process. The result is a low poly 3D model fully texturized ready to use and imported in many 3D viewers. Normally we use the Unity 3D technology (http://unity3d.com) to visualize and interactively navigate 3D models. The Unity plug-in is available for all the major browsers (IE, Firefox, Safari) and platforms (Windows, OsX). Our interdisciplinary collaboration is a contribute to try an innovative solution for the accessing and managing the information in its context.**

Keywords-component; web-based visualization, sarcophagi, relevant information, catacomb, 3D Gaussian.

I. Introduction

In Cultural Heritage the information is often gained from different sources and in varying formats, and to deal with a uniform treatment of heterogeneous data is not easy. The problem arising therefore is: how to provide a unified management methodology of the information and to enable an access for this kind of information to large audiences [1]. Moreover the objects have often a strong 3D component and cannot be easily represented with a 2D map. The use of the new technologies has also changed the perception and interaction with the analysed object in the investigations.

The application of 3D technologies to the Cultural Heritage gives requirements on the underlying technologies in terms of accuracy, performance and usability providing rich interdisciplinary research and development opportunities [2-3].

Virtual reality, can recreate an incomplete or lost object. The Archaeology and Cultural Heritage domain is characterized by an increasing volume of 3D digital content, and one main focus of interest remains the reconstructions for virtual visitors [4]. Some interesting examples of the last years are the applications as in Persepolis [5], for the Almaqah Temple of Yeha in Ethiopia [6], the historical Baalbek [7], and the Villa Adriana in Rome [8].

The attractiveness of such environments allows the researchers, to simulate the structure and artefacts in their context. In situations of environments with accessibility

978-1-4673-2565-3/12/$31.00 ©2012 IEEE

Pecchioli L., Mohamed F., Pucci M. & Mazzei B. (2013). Museum of the sculptures of the basilica of Saint Silvestro integrating the visit at the catacombs of Priscilla in Rome. In Proceedings of Built Heritage 2013, Monitoring Conservation Management, M. Boriani, Edited R. Gabaglio & D. Gulotta (Eds.), (Italy) ISBN: 978-88-908961-0-1

Museum of the sculptures of the basilica of Saint Silvestro integrating the visit at the catacombs of Priscilla in Rome

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1 Intoduction

The use of the new technology in the Cultural Heritage has changed the perception and interaction in every field of research and market. The technologies can improve the experience and help a widespread dissemination and new ways to promote the interaction among users and manage big volumes of information dynamically are improved. Web applications are increasingly used, because they allow access from any computer, while keeping a centralised repository of information. The creation of an interactive 3D visualization can have an important role to record the documentation in Cultural Heritage, because it allows the representation of a context that can be easily understood by all users [Guidi et al, 2009].

Today the Virtual Reality (VR) and the Augmented Reality (AR) belong to the language of the Cultural Heritage, together with the commonly used terms like stratigraphy, laser scanner and thermography. There is an increasing interest in developing 3D reconstructions of towns, monuments, archaeological sites, museums during different historical eras and before and after an intervention of preservation [Manferdini&Remondino, 2010].

Nowadays the people can visit and retrieve information in a museum in several ways. The Medelhavsmuseet (Museum of Mediterranea and Near Eastern Antiquities in Stockholm) has planned to digize its collection in 3D with photos and X-ray scans, allowing museum visitors to explore the mummies in a way similar to what archaeologists do when they are looking for novel discoveries from ancient remains[1].

An important contribute of the technologies is that to help the accessibility of a context located where the geographic-political situations do not allow the visit of tourist people. In these cases virtual reconstructions as web application can archive and share information everywhere. This aspect is a common problem for many countries, e.g. the Museum of Zafar in Yemen (built on 2002). Zafar Virtual Museum hosted by the Heidelberg University and the 3D web application are a good example of an interdisciplinary effort realised with limited resources. The site's inaccessibility and the political unrest prohibit visits by foreign tourists and scholars. The project of the Zafar Virtual Museum communicates knowledge on important and little-known Himyarite artefacts exhibited [Pecchioli et al., 2012a].

Celebrating the 100year Anniversary of the Austrian Excavations in Giza, the Kunsthistorisches Museum Wien curated a special exhibition about this event. Beside of digitizing of the original documentation from the excavation various 3D reconstructions were created. On the technical side, state of art interactive presentation methods allowed to perceive information at different levels [Kulitz & Ferschin, 2013].

If we analyse the the roman context , more close our case, there are interesting projects as: the Centrale Montemartini (Musei Capitolini), located in of industrial archaeology context and converted into a museum. The visitors can find a virtual tour in the website and can download an "application" for mobile device to receive information from the network of twenty civic museums of the city[2]. This short list of projects show how we can use the new technologies as an instrument to improve the accessibility to information in its context, as we aim in our project, the museum of sarcophagi in the basilica of Saint Silvestro.

2 History

The museum of the sculptures of the basilica of Saint Silvestro, collets 471 pieces of sarcophages dated between the beginning of the III century and the first half of the IV century [Tolotti, 1970].

The Basilica of Saint Silvestro was built in the early twentieth century on the foundations of a structure built at different times during the Late Antiquity. The south-east basilica was originally conceived as a space for burials and is currently used as storage of archaeological materials, found during excavations of the last century. The basilica is connected through two entrances to underground tunnels of the catacomb. The underground microclimate influences very strongly also the above environments creating significant of condensation and humidity problems. A monitoring system allowed us to control the situation before and after the project.

Barbara Mazzei, Laura Pecchioli

WEB-BASED VISUALISATION FOR ENVIRONMENTS WITH CLIMATE PROBLEMS: FROM QUEDLINBURG TO ST. TECLA

ISEE Web Application Case Studies

INTRODUCTION

The use of new technologies in cultural heritage is increasing; we present a novel example encompassing both a diagnostic tool and data storage.

The use of technology as an investigative tool for visualisation and data storage has brought new topics requiring knowledge of the subject and an interdisciplinary collaboration to understand the »different languages« in the fields of application (photogrammetry, virtual reality, geographic information systems, etc).[1] There are new technical professionals, qualified but without any real training in cultural heritage. Therefore, cooperation between people who know the subject of investigation, produce the information and need to store it, and those that »translate« these requirements into computer language with an effective display[2] is often required.

In the present work we will focus in particular on the restoration field, where the information is related to several kinds of documents in various formats. Furthermore, the objects studied are not so easily reduced to a 2D representation without loss of information.[3] Using a 3D environment will allow a closer adherence to the real world (e. g. preserving location-related data) and respect the spatial relationships among different components.[4]

We mainly present two case studies about the visualisation and accessibility to information in mural painting contexts with climate problems: the crypt of St. Servatius in Quedlinburg in Germany and the cubicle of St. Tecla in Rome. The results of the restoration have been inserted and displayed in a 3D web application using an innovative method called ISEE, which presents itself as a new means of access to information in real time and in its context.

Where you have accessibility problems, as in high humidity environments, it is very important to maintain the stability of the microclimate. Using 3D virtual visualisation, achievable through a web application, allows us to have even a greater diffusion of acquired data and the enhancement of the restored monument without coming into physical contact, thus avoiding any changes to the microclimate.

Sharing the results of a restoration work, especially when dealing with specific problems and situations, and developing new solutions and new application methods is extremely important to expand the field of research and to obtain feedback on the validity of the procedures taken.

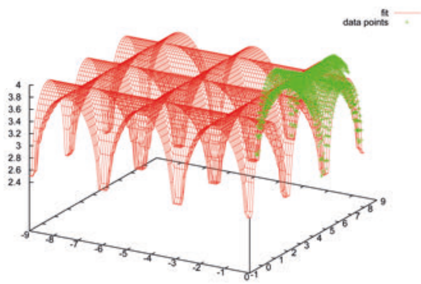
THE FIRST CASE STUDY: THE CRYPT OF ST. SERVATIUS IN QUEDLINBURG, SACHSEN-ANHALT, GERMANY

The development of the method called ISEE started from a case study on the crypt in St. Servatius in Quedlinburg, in collaboration with Prof. Heinz Leitner[5], Hochschule für Bildende Künste Dresden.

Between 2000 and 2007 an important investigation and conservation program was realised extensively using Geographic Information System (GIS) format as a documentation tool and a »base map« consisting of high-resolution rectified geo-referenced photos. The crypt presented different types of information related to the restoration and, in particular, by using a 3D scanner a cloud of points and rectified images corresponding to the ceiling was produced. Moreover, the students inserted information using a GIS program with the orthophotos as reference system.

We used a parameterised surface to describe the ceiling of the crypt where the paintings are (Fig. 1). The

[1] The parameterised surface of the crypt in St. Servatius in Quedlinburg



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kermes

RESTAURO, CONSERVAZIONE E TUTELA DEL PATRIMONIO CULTURALE

ANNO XXX / LUGLIO - SETTEMBRE 2017 / 25 €

POSTE ITALIANE S.P.A. - SPEDIZIONE IN ABBONAMENTO POSTALE D.L. 353/2003 (CONV. IN L. 27/02/2004 N.46) ART.1, COMMA 1 NO/TO/1216/2017 DEL 30.05.2017 TASSA PAGATA/TAXE PERÇUE/POSTAMAIL INTERNAZIONALE

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Applications of 3D technology in cultural heritage

Digital survey and 3D digitalization

Digital reconstruction, 3D - printing and Augmented Reality

Accessing and Information System

ISSN 1122-3197

9 788832 029055

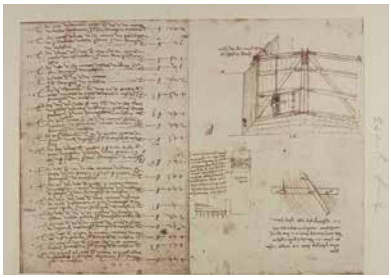
Sommario

In copertina:
Campagna di ripulitura (2016) dell'area Nord del Foro di Ostia. Dettaglio delle superfici (Ostia-Forum-Projekt).

Attualità

Dossier
Applications of 3D technology in cultural heritage

DIGITAL SURVEY AND 3D DIGITALIZATION



MuPris – MUSEUM OF PRISCILLA IN ROME
SfM DIGITAL SURVEY APPLICATION AND MODELING

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KEY WORDS: Sarcophagus, 3D modeling, Photogrammetry, Database, 2D interface, ISEE software, Structure for Motion

ABSTRACT:

The basilica of St. Silvestro was erected in 1907 on the foundations of two ancient rooms which were situated originally in a cemetery enclosure surrounded by several mausolea which most likely contained the sarcophagi, excavated between 1890 and 1906. The small Northwest basilica resulted from several transformations around the burial place of the martyrs Felice and Filippo, where also the pope Silvestro († 335) wanted to be buried. The presence of these venerated burials led to the realization of a second building thought to be an indoor cemetery, for which several graves where planned following an organic approach. These are today visible through the new floor. Among numerous marble fragments of sarcophagi, found in the archaeological excavations, the most important piece is a well preserved sarcophagus dated around the III Century A.D., graven with scenes from the everyday life and from agriculture and sheep-farming activities. This piece is the object of this study, a robust challenge for the digital survey, because of the complex characteristics of the sculptures and their small size details and last but not least the difficulties linked to the light subsurface dispersion of the marble. For these reasons the survey was based on the Structure From Motion process, operating using a digital SLR camera and a specific SfM software. The main vantages of this choice are the reduction of the instrument costs and their practical management: all was done with a good quality camera, a tripod and some studio lights, while a single, middle price, software was used to produce the final digital 3D model. The final results, edited and optimized in different solutions for multimedia presentation and prototyping were soon ready for further usage, like the implementation in the multimedia detail database.

1. MANUSCRIPT

1.1 Introduction

Today the use of new technologies in Cultural Heritage is an important step for analysing the patrimony of humanity and enhancing its documentation. In the last years the digital surveys made with 3D laser scanner technologies brought on numerous case studies aimed to digital representation and interpretation, while the digital and multimedia solutions have renewed and expanded the range of communication tools available for the dissemination and even for the protection of Cultural Heritage (Kulitz et al., 2012; Locatelli et al., 2012).
The main problem connected to the production of meaningful innovation and important contents is often the fact that this kind of technology requires high costs, often beyond the intentions of institutions and the possibilities of a single researcher or scholar. This is not only about the cost of the tools, while they can be found for rent at reasonable prices, but regards the meaningful investment required in post production of the contents and development of the final products. During the last three decades, the field of image-based technologies has been improved, such as the Structure from Motion (SfM) (Ullman, 1979). A large number of digital cameras on the market contain efficient, passive, lowcost sensors adequate for our purpose (Kersten et al, 2011). Some of these freeware and open source software are easy to use also the typical researcher archaeologists.
A depository of resources will be enable for solution of transferring information characterised from the interoperability for a usage from 3D interactive web applications (Pecchioli et al., 2012a) to web archive for the researchers or 3D models to employ for other future implementations.

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The classical process to produce a 3D model out of a set of pictures consists in a photographic survey of the object made with a good illumination, a subsequent software operation and a final generation of a textured 3D model of the object. The process of development of these processing was quite long through time, but it has reached a meaningful acceleration in the last five years with the production of important and well working software solutions (Agisoft Photoscan) and freeware software package (Autodesk 123D Catch, Microsoft Photosynth and Visual SfM). Case studies of survey in Cultural Heritage using SfM solutions are now really numerous. This is due to the simple approach of the software solution and the very portable set of tools needed to work in this way.
It is possible to consider this solution as a very powerful tool, balanced between traditional and innovative features and available for multiple purposes and needs.
The case study presented in this article required to produce a high quality model of an important and well preserved element through an efficient and economical solution in the use of these photogrammetric procedures.

1.2 The Basilica of St. Silvestro

The Basilica of Saint Silvestro located in Rome and it has the particular characteristic of rising above the catacombs of Priscilla. The Basilica was built in 1907 over the remains of two ancient constructions from the third and the midforth centuries. The original buildings were incorporated in a funerary enclosure and probably they were surrounded by numerous mausoleums (Tolotti, 1970).
Inside the church, the floors of both buildings were tapped in time with the insertion of tombs some graves were placed also