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M. Dellepiane, F. Niccolucci, S. Pena Serna, H. Rushmeier, and L. Van Gool (Editors)

From 3D Acquisition to Augmented Reality: the case of the Charterhouse of Villeneuve-lès-Avignon (Gard, France)

A. Favre-Brun[1] and L. De Luca[1] and M. Florenzano[1]

[1]Laboratory MAP CNRS/MCC, National School of Architecture, Marseille, France

Abstract

The charterhouse of Villeneuve-lès-Avignon (Gard, France) was created by Pope Innocent VI in the XIVth century. Several times, it was transformed, like its church. Under the program 3D[Monuments] of the Ministry of Culture and Communication, this building was the place of campaigns of digital and photographic surveys. The goal was, in first, to reconstruct the current state of the building, then to propose a restitution of its post revolutionary state. A database which contained documentation, related to the 3D objects, was created. The development of 3D digital mock-up led us to think about the reliability of documentary sources. The site of the charterhouse has been selected as the testing ground for the study of documentary data uncertainty realized as a part of a doctoral thesis.

Categories and Subject Descriptors (according to ACM CCS): I.4 [Computer Graphics]: Computing Methodologies—Image Processing and Computer Vision ; J.5 [Computer Graphics]: Computer Applications/Arts and Humanities—Architecture

1. Introduction

The abundant documentation resulting on literary studies and digital surveys realized on the charterhouse of Villeneuve-lès-Avignon (www.chartreuse.org/16/la-chartreuse-numerique) implies an organisation in a database. For the national program for 3D scanning 3D[Monuments] (www.map.archi.fr/3D-monuments), a 3D digital mock-up of the building, based on lasergrammetric surveys of the National School of Geographical Sciences (ENSG) and then, completed by our digital surveys. The goal is to link historical documents with its 3D representation in order to inquire the 3D model. The NUBES described platform (www.map.archi.fr/nubes), developed internally, is an informative system on an architectural scale which exploits the relations between the 3D representation of the building and heterogenous information coming from various technical and historical studies [DBS*10]. It will be accessible to archaeologists, architects, historians or restorers for the retrieval of data and integration of documentation. The first objective of our project was to create a digital archive of the current church by carrying out laser and photographic surveys. We then employed these records to provide a restitution of the building in its post revolutionary state (1791) by analyzing descriptive texts. The problems encountered during the restitution of hypothetical objects and architectural structures disappeared led us to think about the reliability of documentary sources. Our study addresses this problem by putting in place arrangements for representation and visualization of the confidence to inform the 3D model.

In first, we will introduce our subject by a summary of the charterhouse history and a description of digital works (surveys and modeling). We will then discuss the study of documentary sources and the assessment of the uncertainty granted in documentary sources. Finally, we will present briefly the visualisation system developed from the 3D model.

2. History of the Charterhouse and Studies

The charterhouse was founded by Pope Innocent VI from 1352 and extended, with especially the church and cloisters, until the French Revolution (1789). Then, the monastery has been sold and liturgical objects were dispersed. During the XXth century, expropriations of families and restoration campaigns were undertaken. It was classified like Historical Monument in 1905. Since 1990, the ancient monastery houses the National Center for the Performing Scriptures

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which organizes and hosts exhibitions of artists in residence. The first studies of the charterhouse are difficultly dated with precision. Indeed, since its foundation, it has been extensively documented. The heteregenous collected documents are drawings, texts, photographs, audiovisual recordings or maps. Recent scientific studies: reports of archaeological studies [NU05] or monographs ([SV06]) provide more accurate data, produced by powerful technics and tools (scanners, laser tachometers, high resolution photos). The building itself and the artefacts are also analyzed, as well as oral sources from scientists or persons unknown.

3. 3D Reconstruction and Hypothetical Restitution of the Church

3.1. Digital Processing of Current Volumes: Lasergrammetry and Photographic Acquisition

Following lasergrammetry campaigns of the ENSG conducted since 2005 and collaborative works between archaeologists, architects, engineers and art historians, we organized new acquisition campaigns to scan architectural elements missing from previous surveys, in addition to decorative objects. We choose specifically the church because it has been widely documented and offers many alternatives of spatio temporal 3D restitution (architectural structures destroyed, decorative elements diseppeared). Several laser scanners were used to acquire the volumes of the buidling, depending on their complexity or their distance. Thus, the architectural and sculptural distant objects were scanned with both long-range scanners Mensi Trimble GX and GS-200. The tomb of Innocent VI was scanned in high resolution with the same long-range Trimble GX scanner. The optical triangulation scanner Konica Minolta Vi-910 was used for objects carved located a short distance. Finally, the FARO Photon phase-based scanner has been exploited to the acquisition of the general structure of the high altar. All these points clouds obtained, ie millions of coordinates, have undergone successive treatments (registration, cleaning, cutting) before the 3D reconstruction step (Fig. 1 and 2). Then, based on these data, we have reconstructed the current state of the church by semi-automatic meshing and 3D geometric modelisation.

We also conducted two kinds of survey photographic campaign: one for the existing objects kept in several places (such as paintings), and the second campaign of panoramic photographic records, to produce images of space on 360°. Panoramic images were treated from collection of photographs with Autodesk Stitcher. The goal was to integrate them into an interactive visit 3D real-time.

3.2. Proposal for a restitution of the postrevolutionary state

We have proposed, in collaboration with historians of the monument, an hypothetical reconstruction of the church in

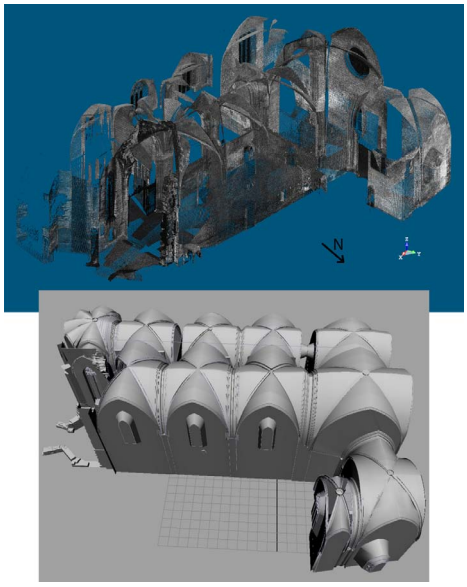

Figure 1: *Points cloud of the current church and 3D model.*

Figure 2: *Digital survey of Pope statue, points cloud and 3D model.*

which we have relocated the decorative elements (paintings and liturgic objects). Two detailed texts were used: a description of 1743 [Val91: 387-400] and the inventory listed in 1791 [GM91]. For the disappeared elements (lights, stalls, flooring), we have compared textual sources with contemporaneous objects preserved in other places (Fig. 3). We proceed regularly to updates of the 3D digital model, based on the documentation analysis.

This restoration work of the church, based on these documents, has raised many questions about the reliability of documentary sources. Currently, we are trying to illustrate graphically this confidence. The arrangement of the database is a first step to assess levels of confidence that can be granted in documents. We plan to develop and to integrate, within NUBES platform, a specific interface management and visualization of uncertainty.

Figure 3: *Hypothetical state from the inventory of 1791.*

4. Research perspectives of the uncertainty

4.1. Documentary Database

The current collection of sources contains hundreds of documents, supplemented by previous digital surveys (photographs and scanner). In order to study documentary sources, we have defined a classification as follows: graphic material, audio and audiovisual materials, oral sources (evidence scientific and rumor), digital documents (points cloud, 3D model), texts and, at last, material documents (mock-up / model, archaeological artefacts). Thus, the semantic database integrated in the NUBES platform associates, for each 3D model of the hypothetical information, from documentary sources argue that the scientific reasoning for the restitution (Fig. 4). NUBES tools allow to access to documentary sources from 3D objects and vice versa [DBS*10].

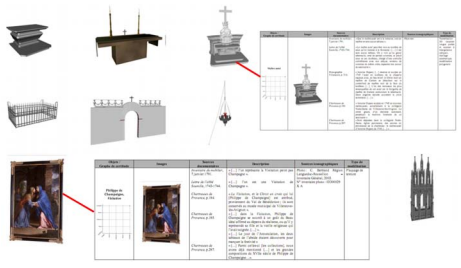

Figure 4: *3D objects restituted and example of the link between documentation and 3D representation.*

4.2. Uncertainty Codification

Data uncertainty problem is present in many fields. So, systems and tools for visualize uncertainty were developed and applied. The assessment and the codification of uncertainty have been defined by various criteria to inquire maps ([Ber73], [THM*05]). In cultural heritage, documentary sources argue 3D restitution and give to work a scientific validity. To date, common depiction tools to data uncertainty in a 3D mock-up are transparency, lines thickness or false colors ([SMI99], [KSC04], [BD06]).

We present here results to a well known existing objects of the church (the high altar). The method being tested is an uncertainty graph (Fig. 5), developed on two axes: the sources specific to the object (Y axis) crossed with the morphological spatio criteria on X axis (as location, dimension or conservation status). It appears in the 3D model when an object is selected and, then, from it, we can access to documents which argued its restitution. We are defining, currently, graphic indicators which assess the reliability level: a red dot is used to define an information with a high level of certainty, an orange dot is employed to specify uncertainty (imprecise or incomplete data) and no dot indicates a lack of information. Our current experiment must be thorough, based on mentioned previous works, especially on the visual and graphics codes. Furthermore, we are thinking of a way to determine the granularity of the uncertainty on several levels scale, from the type of documentary source to the information itself. Finally, the temporal dimension is, for now, not considered because the current 3D model represents the church in 1791. However, we integrate it into the final state categories related to the temporal aspect to provide a digital 3D model evolving in time.

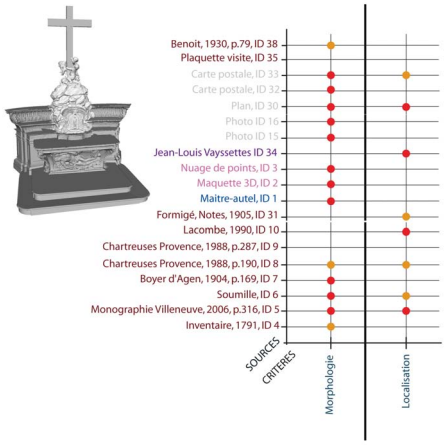

Figure 5: *Uncertainty graph, specific to the high altar.*

5. Visualization System

The visualisation device, previously introduced, is a virtual visit of the church, based on an hybridization between real and virtual: a current image calculated from the 3D model of the restored state is superposed on a photograph 360˚(Fig.

6). It was developed with Virtools Dev (www.3ds.com/products/3dvia/3dvia-virtools). The major interest is to present each area of the church on 360˚in its current state and restituted. Moreover, it is possible to access to specific information to objects (title, author, date).

Figure 6: *Hybridization device between real and virtual.*

In its current state, the hypothetical digital mock-up is integrated into the multimedia show "Genius Loci". This is an installation of augmented reality at scale 1 of The anamorphosis principle is based on correcting the image from a fixed observation point. The scenario for this show The goal will be to set up the system for multiple points of view, calculated according to the location of a sensor.

6. Conclusions

The work carried out over several years to acquire the current state of the church and its hypothetical return is in progress as part of a PhD thesis on the uncertainty assessment of documentary sources. Moreover, tools and systems developed were integrated in cultural diffusion, through two applications. The first is the 3D interactive visit of the church and the second is the multimedia show "Genius Loci", an installation of augmented reality at scale 1 of anamorphic projecting images of the 3D model on the walls, set up for one point of view. This system, which immerses the spectator into the church from 1791 until its dematerialization, was released in July 2011.

Currently, the interaction 3D digital mock-up / database allows to test various approaches to depict the confidence of documentary sources which are the basis for refunds. The tracks mentioned above are under development. Our reflection on the uncertainty depiction of sources has to be refined, as the definition of criteria for assessing levels of trust, especially by the introduction of graphical codes that need to express the user to the comp (computer programmer, architect, archaeologist, historian).

7. References

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