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From the archival documentation to standardised web database and 3D models

The case study of the Camaldolese Abbey in Volterra (Italy)

Eliana SIOTTO[1, 2] | Marco CALLIERI[1] | Paolo PINGI[1] | Roberto SCOPIGNO[1] | Laura BENASSI[2] | Alice PARRI[2] | Denise LA MONICA[2] | Andrea FERRARA[1]

[1] CNR – ISTI Visual Computing Lab, Pisa, Italy | [2] Scuola Normale Superiore – LARTTE, Pisa, Italy

Abstract: Our age is characterized by the ease of communication and fast and free exchange of data. The use of standards and a common approach to recollect, organize and present the documentation gives a great advantage for the knowledge and dissemination of the archaeological, artistic, historical and conservation information of Cultural Heritage. Establishing a *"correct" documentation* policy is the main goal that guided our initiative for the documentation, preservation and valorisation of the monumental complex of the Camaldolese Abbey in Tuscany. In this project we retrieved the paper documentation in the Historical Archives of the Tuscany Region, to study the historical and conservation data of the monumental complex. Digital technologies have been used to support storing and access to this important information, including also data to monitor the current state of its preservation. The documentation has been digitized and is accessible through a web database; this resource was designed by following the Italian National standards proposed by Central Institute for Cataloguing and Documentation (ICCD). The current state of conservation of some parts of the building has been documented by taking panoramic images or panoramas (360º images) and by the acquiring 3D digital models. In particular, panoramas are used to document the state of preservation of frescoed rooms, while geometric 3D models are produced to document the degraded areas of the church, which require a constant monitoring. Moreover, an analytical virtual reconstruction of the church was modeled to depict its status before the building's collapse. The main goals of this work are to provide a good-practice example on how to document and disseminate on the web the knowledge available on an endangered monument, following national and international standards, in order to make the knowledge widely accessible. In this way, it is possible to disseminate and enhance the old results with new analysis and interpretations of documents that can be easily shared with other researches, conservation experts and the ordinary public.

Keywords: Archival documentation, Web database, Panorama images, Virtual Tour, 3D model

Introduction

The Camaldolese Abbey is one out of the four monumental complexes, located in Tuscany, chosen as case studies in the ArTeSalVa project (http://artesalva.isti.cnr.it/). ArTeSalVa (Architecture, Technology, Safeguarding and Enhancement of historic buildings) has been a joint effort between the Scuola Normale Superiore of Pisa – LARTTE (http://www.sns.it/en/ricerca/lettere/lartte/) and the Visual Computing Lab of the

Italian National Research Council (http://vcg.isti.cnr.it/) in Pisa, in collaboration with La Sterpaia by Oliviero Toscani (www.lasterpaia.it/it/chisiamo.htm) and the IT company NoveOPiu (www.noveopiu.com).
The aims of the ArTeSalVa project are the study and the definition of new methodologies for the knowledge and enhancement of historic public and private buildings located in Tuscany, and which are currently in a state of decay or are underused (SETTIS et al. 2012).
The re-use is a natural form of survival for historical public and private buildings. Therefore, to find innovative solutions that ensure a longer life and maintain cultural, social and economic values is necessary. The re-use can also enhance interactions with the context. Through an increase of the knowledge, the historical buildings once again become the vehicle of intangible values and potentially become an important factor in the development of local economies (BENASSI et al. 2012).
The core idea of ArTeSalVa project was to combine the consolidated archival research with the adoption of new documentation and presentation technologies. The final goal is to produce a better insight on the history of those buildings and to document the current conservation status. In particular, on the one hand the project aims for increase awareness of the different communities on the value of these buildings, by means of a focused historical and scientific research and the use of new technologies in order to obtain a standardized and visual documentation of the current conservation status. On the other hand, it desires to communicate the past of these buildings and their previous uses through innovative digital presentation channels. All these steps are essential in order to activate the enhancement process and offer more opportunities for a regular preventive conservation, an accurate restoration and active re-use of this Cultural Heritage. Therefore, the goal of the project is the creation of a free integrated information base to help the specialists to understand, promote and restore the Architectural Heritage. For this aim, the project has used available standards and a common approach to recollect, organize and present the documentation employing a combination of traditional archival research and modern digital technologies

The Camaldolese Monastery in Volterra: a short history of the building

The Badia Camaldese is located outside the city walls of Volterra (Pisa, Italy) on top of a promontory whose front edge is characterized by steep rocky cliffs (Fig. 1). The building's history is closely connected to its particular topographical location as well as to the events that took place at the ancient church of San Giusto al Botro. Tradition tells us that the first nucleus were the two chapels built at the burial sites of the saints Giusto and Clemente during the second half of the 6th century. After the destruction of these original chapels occurring during the Lombard invasions, an effort to rebuilt and expand those buildings was done at the end of the 7th century. The complex was completely restored around the end of 10th century as a Benedictine monastery. The administration of the monastery was later handed over to the Camaldolese order. The Monastery was enlarged and embellished in the 16th and 17th centuries by famous architects and painters. During the second half of the 18th century, it underwent a general reorganization. In 1767 an earthquake caused structural damages to the church. The abbey was suppressed in 1808 by Napoleon, but the Benedictine monks took possession back in 1816. However, it was abandoned after the earthquake of 1846 and definitely after the Italian unification (FURIESI 2008; LA MONICA in press). In 1866, the property of the complex was partly transferred to the State and partly alienated to private parties. In particular, in the last few

years the complex has been partially restored and secured by Volterra's local bank Cassa di Risparmio (fig. 2). Thanks to these relevant activities, a part of the complex monastery is now accessible to the public and used for performing festivals, arts and cultural events to the community.

Fig. 1 – Camaldolese Monastery in Volterra, Tuscany (Copyright: ArTeSalVa project)

Fig. 2 – Details of inside of the Camaldolese Monastery before the last restoration activity (Copyright: ArTeSalVa project)

The results of the ArTeSalVa project

Establishing a "*correct*" documentation policy is the main goal that guided this multidisciplinary research that used the traditional archival research and the new technologies both for the documentation of the current conservations state of the monastery and for the dissemination of the information gathered. The documentation has been digitized and is accessible through a web database based on the Italian National standards produced by ICCD (http://www.iccd.beniculturali.it/index.php?it/115/standard-catalografici); while the images, panoramas and 3D models have been acquired and are available in standard 2D and 3D file formats.

The Database

The archival researches were conducted in several Italian historical archives and permitted the collection of many important documents and information concerning the reconstruction of the architectural and artistic history of this monastery. All data is organized in an open source database (fig. 3) freely available on the project website (see at http://artesalva.isti.cnr.it/en/database, access available to registered users).
The web database is developed in eXtensible Markup Language (XML) and its extensions (XQuery and Xpath), because this technology has been established as the most widely used standard for representing structured information. The flexibility of these tools is the key reason for the adoption of the XML technology in order to represent complex semantic content such as CH documentation (BECKER et al. 2009). Indeed, it has been adopted as a standard for several national and international institutions as the Italian ICCD, an important Institute under the Ministry for CH and Activities (MiBAC), which defines the standards, tools, rules and methodological guidelines of General Information System of Cataloguing, the SIGEC (http://www.iccd.beniculturali.it/index.php?en/118/general-information-system-for-cataloguing). Indeed, the collected data is been coded using the format of "Card A" for the Architectural Heritage and this of "Card AUT" for the authors. The format for the codification of the item "source of information" (in Italian called

"fonte") was developed by taking into account interoperability. For this reason was not possible to use a single card already coded. The web-based system (developed with PHP, MySQL, HTML, CSS and JavaScript) is in charge of an integrated front-end into the Content Management System (CMS) to manage the website. The system provides a file system for managing XML files via HTTP by HTML format. That is possible after the transformation of XML file in XSLT using standard PHP libraries. A RESTful service API in PHP was created to access to XML web service system to retrieve information, which are stored and managed in a system for XML. The database can be searched and visualized in two ways. A free search allows users to perform full text retrieval, while a specific mask (Fig. 4) allows users to search according to the structure of the encoded data. A user-friendly search interface quests the data directly on the XML database where HTML / CSS / JavaScript codes are generated using standard PHP. In this way, all data can be consulted by any web browser that meets the ACID 2+ criteria.
Therefore, the ArTeSalVa web-database allows to manage the functions that refer to three fundamental processes: the planning of the cataloguing project, the production (data entry, creation of relations and scientific content check) and the free use (validation, publication and exchange data by interoperability).

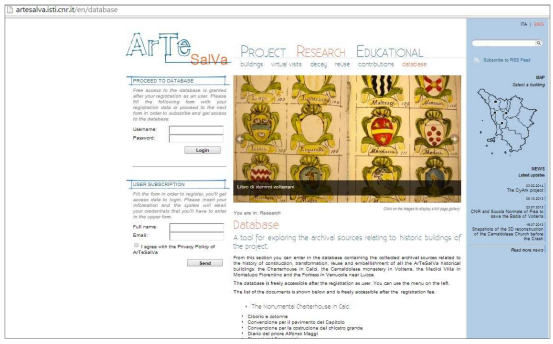

Fig. 3 – Homepage of the ArTeSalVa database (Copyright: ArTeSalVa project)

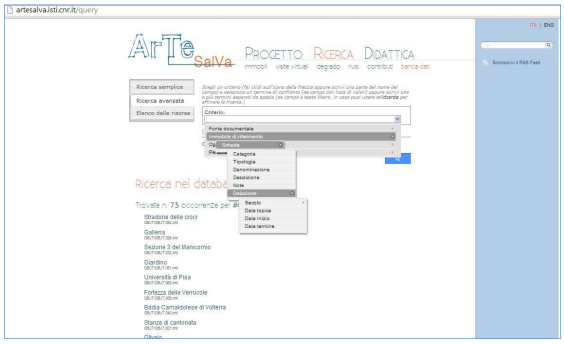

Fig. 4 – Research mask of the ArTeSalVa database (Copyright: ArTeSalVa project)

The high-resolution 3D model

Preservation of Architectural Heritage (AH) is strongly interconnected with a regular maintenance of monuments, defining thus the preventive conservation as a real necessity in ordinary practice. The methodology adopted in the ArTeSalVa project is based on the opinion that the 3D geometrical models have a double scientific and practical value. Firstly, they provide support for advanced preventive conservation programs, helping the sustainable interventions and maintenance over time. Secondly, the virtual models have a great potential for knowledge sharing and dissemination via web, covering both the specific thematic interests of experts and of the general public (SCOPIGNO 2012).
Therefore, we decided to sample a high-resolution 3D model of the inside and outside of the monastery church to document its precarious state of conservation. A time-of-flight interference scanner, a FARO Photon 120, was adopted, which is very fast (2-5 minutes per scan) and precise (2-3mm accuracy). The whole church of the Camaldolese Monastery was scanned taking 24 circular scans, in around 4 hours. In addition, panorama photographs were taken, using a Nikon camera with 10.5 mm lens, both to map the color

data over the 3D model in a subsequent post processing phase and to generate a *Badia Virual Tour* (see sub-section *Panoramic Virtual Tour*).

The data has been processed using MeshLab (http://meshlab.sourceforge.net/), a leading open source mesh processing system developed by CNR-ISTI (CIGNONI et al. 2008; CALLIERI et al. 2011), which supports various input and output 3D formats. The 3D model produced has about 108 million points at 5mm of resolution (http://artesalva.isti.cnr.it/en/virtual-visits-badia-volterra); it is enough accurate to be used both for the visualization to the general public as an example of peculiar architecture, and for helping the precise documentation and assessment of the current conservation status (figs. 5 and 6).

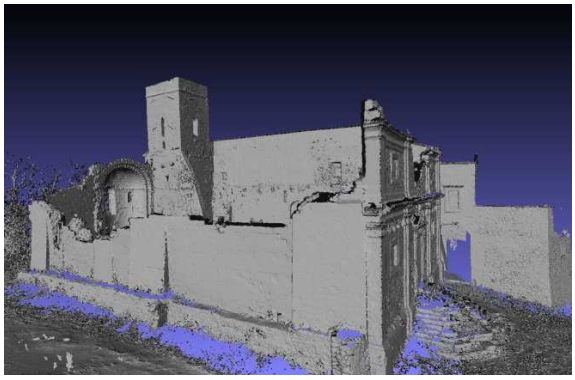

Fig. 5 – Union of range maps of the Church in the Camaldolese Abbey in Volterra, Tuscany (Copyright: ArTeSalVa project)

Fig. 6 – Images produced from the high-resolution 3D model of the Church in the Camaldolese Abbey (Copyright: ArTeSalVa project)

The virtual reconstruction

On such degraded or transformed architecture, to build a digital model(s) depicting the status of the artwork in selected moments of its life is important. This means reconstructing virtual models on the base of current evidence and on available knowledge on its story (written documents, historical plans and technical drawings, paintings, historic photographs, etc.). 3D virtual models (either sampled from reality or reconstructed form available fonts) are useful tools for improving access to several data that could support innovative programs for preventive conservation of AH and to contribute to its sustainable maintenance over time. The activity carried out in the ArTeSalVa project has demonstrated that, through an accurate 3D survey of the structures and a rich historical documentation, it is also possible to obtain the basic geometric data of the building in its original shape and also to derive precious information on the construction process and methodologies used in the past (FERRARA 2013; PINGI et al. in press). This information is very important in order to evaluate the structural behaviour of all elements and to detect areas upon which to perform diagnostic tests and also to support restorations. In particular, our activity started from the accurate analysis of the geometric sampled 3D model (generated by data acquired with laser scanning system) and comparing the documents, plans and images found in the historical Tuscany archives (fig. 7). This has allowed reconstructing a scientific virtual model of the Church as it was in the middle 19th century, before the collapse of the building (fig. 8, at right). This analytical virtual reconstruction has allowed discovering unexpected parts of its history (FERRARA 2013; PINGI et al. in press), which were not examined by the literature until now (BOCCI 2003; FURIESI 2008).

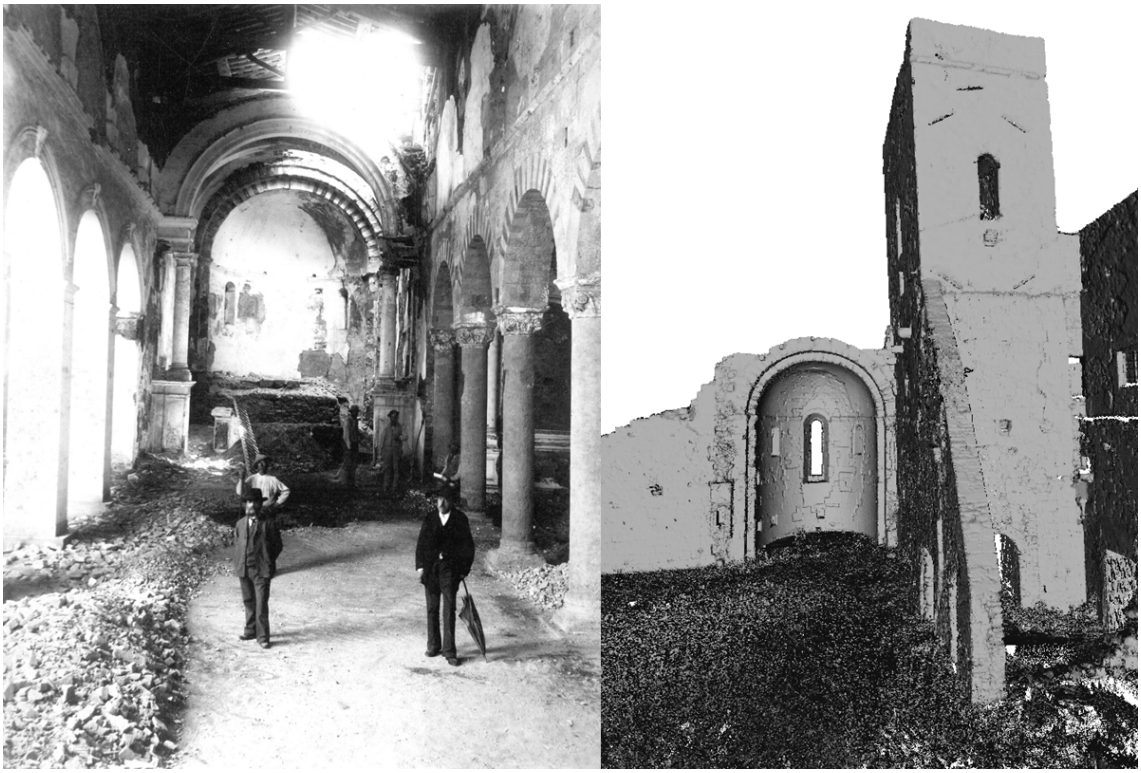

Fig. 7 – Comparison between the historical images of the interior of the Church (after 1895) and the 3D geometric model (Copyright: ArTeSalVa project

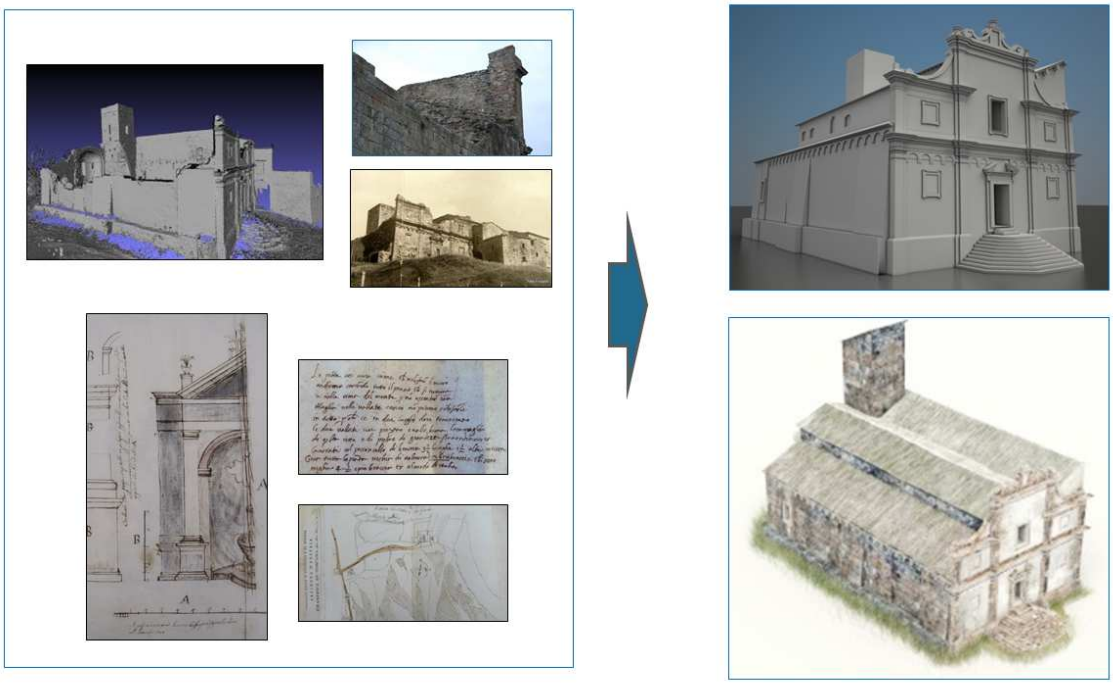

Fig. 8 – Outline of several systematic steps to create a scientific virtual reconstruction of the Church at the mid-19th century (Copyright: ArTeSalVa project)

The panoramic Virtual Tour

Even if the current 3D technologies allow the generation of very realistic 3D models, we should also underline that the massive use of 3D models for fruition to the general public of the entire monastery would be an overkill. Basically, the geometry of most monastery rooms is quite simple and a digitized 3D model would not give to the user much additional value. On the other side, the decoration of the rooms in the main building is mostly made by frescoes unfortunately covered of white paint, therefore for a fully documentation of this situation a 2D image-based acquisition is a better choice than a 3D model. Therefore, the decision was to produce a dense set of interconnected panoramas to implement the *Badia Virtual Tour* (http://artesalva.isti.cnr.it/en/virtual-visits-badia-volterra), which resulted into a simple but effective mean to document and convey its state of conservation before a recent restoration of the staircase and facade of the church (Fig. 9). Beside the medium resolution panoramas (10–15 MPixels) used to build the virtual tour, a very high resolution panorama (about 100 MPixels) has been captured in the refectory with the preserved important frescos (CONIGLIELO 2001; LA MONICA in press), to provide an effective documentation for art historians and restorers (fig. 10). Figure 11 shows the graphical user interface for build the interactive virtual tour of the Camaldolese Monastery in which all panoramas are linked to each other via hotspots or via the overview map (at right-bottom corner) or via panoramas index (at left side). Thus the user can zoom in and out, rotate the panorama in all directions, and navigate through all panoramas by clicking the hotspots or the marked positions in the map (fig. 12). The tour is enriched by images of the details and art-historical information (or Archive documents) using XML-based programming (fig. 9). This integration allows to encourage the user interest in and improving its cultural (and technological) knowledge. Indeed, this easy data access arouses more interest and a delightful interaction with virtual reality. Therefore, this choice has shown several advantages: first, it is easy to deploy through a website; second it is simple to use for the people with no expertise with the 3D model interaction; finally, it still provides a complete and immersive view at 360 degree of the building and its decorations.

Fig. 9 – Facade of the Church in *Badia Virtual Tour* enriched of images and art-historical information (Copyright: ArTeSalVa project)

Fig. 10 – Unrolled panorama of the frescos painted by Donato Mascagni (1595-1598) in the dining hall of the Camaldolese Monastery in Volterra, Tuscany (Copyright: ArTeSalVa project)

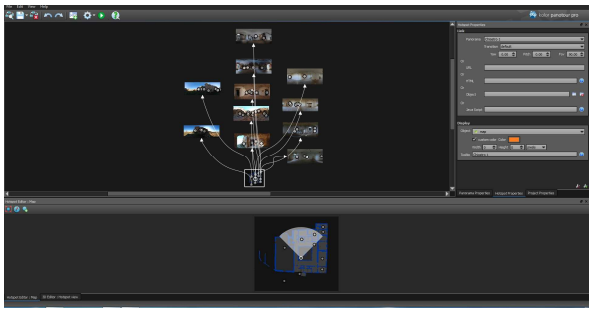

Fig. 11 – Creation of *Badia Virtual Tour* using panorama images (Copyright: ArTeSalVa project)

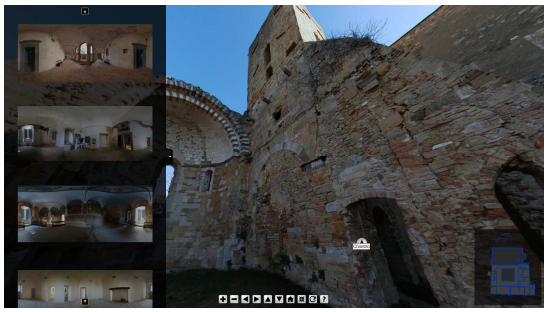

Fig. 12 – A different way to see a *Badia Virtual Tour* of Camaldolese Monastery (Copyright: ArTeSalVa project)

Conclusions

This project provided a good-practice example on how to document and disseminate on the web the knowledge available on an endangered monument, following national and international standards, in order to make the knowledge widely accessible. Therefore, this data can be used both to study the current state of conservation of the building and support the conservation or restoration actions, and to disseminate them to the general public and local authorities. In this way it will be possible to modify and improve the old results with new digital and scientific analysis or dissimilar interpretations of the documents that can be easily shared with other researches from different fields.

Acknowledgements

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