CENOBIUM
CULTURAL ELECTRONIC NETWORK ONLINE: BINDING UP INTEROPERABLY USABLE MULTIMEDIA

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CENOBIUM project is a multimedia presentation of Romanesque cloister capitals from the Mediterranean region. High-resolution digital photographs, 3-D models, and panoramas will virtually link the capitals to their original surroundings, thus representing them within their original architectural and conceptual contexts. The cloister of Monreale is the starting point of this project, which combines classical and innovative methods of Art History with the latest in multimedia data technology.
The paper describes the different acquisition and documentation; it also outlines the main components of the system which will allow the user to virtually explore the cloister.

1 INTRODUCTION

The CENOBIUM project (Cultural Electronic Network Online: Binding up Interoperably Usable Multimedia) faces the necessity to improve scientific and educational communication on the one hand and public information systems on the other hand, integrating new investigation instruments, not systematically connected until now. It will provide a web-based, openly accessible work environment, which includes 3D models created by scanning, CAD-representations, digitized historical photographs and digital photography of the highest professional quality. The technical work will be devoted to the integration and extension of available technologies (database, image-viewers, 3D-viewers, content management, etc.) now dispersed and not inter-operative. The project points to the introduction of multimedia investigation of artworks as a regular research-instrument in the service of its different user groups. The specific case study considered for the assessment of our approach is a selected group of important capital-cycles in medieval cloisters of the Mediterranean region, starting with the cloister of Monreale.
The art-historical material is highly adequate for multi-dimensional representation, given the 3-dimensionality of the capitals and their spatial connection with the surrounding architecture. The monastic complex was commissioned by King William II and executed between 1174 and 1189. It unites various artistic currents of Romanesque monumental sculpture into an architecturally homogeneous setting, and it contains more than 100 different capitals.
In this paper we present the first steps of this project, started on 2006. The initial work has been focused on the acquisition and processing of 3D and 2D data. After a very brief overview of related work in Section 2, we describe our data acquisition experience in Section 3. The overall structure of the system which will integrate all the data is sketched in Section 4. Finally, we present our conclusions and the future work in Section 5.

Figure 1: (a) The Monreale cloister, (b) The acquisition setup.

2 RELATED WORK

Many previous works concern the use of 3D technology either to reconstruct digital 3D models of Cultural Heritage masterpieces or to present those models through digital media. An exhaustive description of those works goes well beyond the brief overview that we can draw in this section. We prefer to cite here only some seminal papers on the technologies proposed for 3D scanning and interactive visualization.

Automatic 3D reconstruction technologies have evolved significantly in the last decade. An overview of 3D scanning systems is presented in [1]. Unfortunately, most 3D scanning systems do not produce a final, complete 3D model but a large collection of raw data (range maps) which have to be post-processed. The post-processing pipeline is presented in the excellent overview paper by Bernardini and Rushmeier [2]. Many significant projects concerning 3D scanning and Cultural Heritage have been presented in the last few years [3, 4, 5]. Some of these projects considered also the issues arising when the aim is to sample not just shape but also the reflectance properties of the surfaces [4] and the mapping of this information on the geometry [6,7].

The high resolution meshes produced with 3D scanning are in general difficult to render at interactive frame rates, due to their excessive complexity. This originated an intense research on simplification and multiresolution management of huge surface meshes [8,9] and interactive visualization, where both mesh-based [10] and point-based solutions have been investigated.

3 DATA ACQUISITION AND PROCESSING

The comprehensive acquisition campaign we performed in Monreale was the starting step for the creation of a large database of high quality 2D and 3D data.

High resolution digital imaging: A Sinar P3 digital camera was purchased by the Photo Library of the Kunsthistorisches Institut, providing for the integration of the digital backs Sinarback 54 H and Sinarback eMotion 22, both of them with a resolution of 22 million pixels (sensor resolution 5440x4080 pixel), as well as various Sinaron lenses.

The size of the high resolution digital images is approximately 65 Megabytes (TIFF format uncompressed, 8-bit-per-channel colour depth, 4000x4000 pixels - approximately 33 cm on a 300 dpi printout). A set of 8 photos, documenting a capital, is shown in Figure 2.

Scanning the capitals: High quality 3D models of the capitals have been produced by using a Konica Minolta VI 910 Laser Scanner; since the scanner works at a distance between 50 and 100 cm from the objects, it was necessary to put it on a scaffolding (see Figure 1b).

In the first scanning campaign (February 2006), which lasted for an entire week on site, we were able to scan 20 out of the more than 100 capitals of the cloister. To sample this initial subset we shot nearly 4000 range maps. Each set of range maps has to be processed to convert it into a single, complete and non-redundant 3D representation. As usual, the processing phases are: range maps alignment, range maps merging (or fusion), mesh editing, mesh simplification and conversion into a multiresolution representation, and finally color mapping.

Figure 2: An example of the set of photos for the “W8Sh82” (Dedication) capital.

In order to obtain detailed 3D models, we used the ISTI-CNR tools, which give the possibility to deal with large number of range maps and to produce the final model with minimum human intervention. A complete overview of these tools is presented in [11].

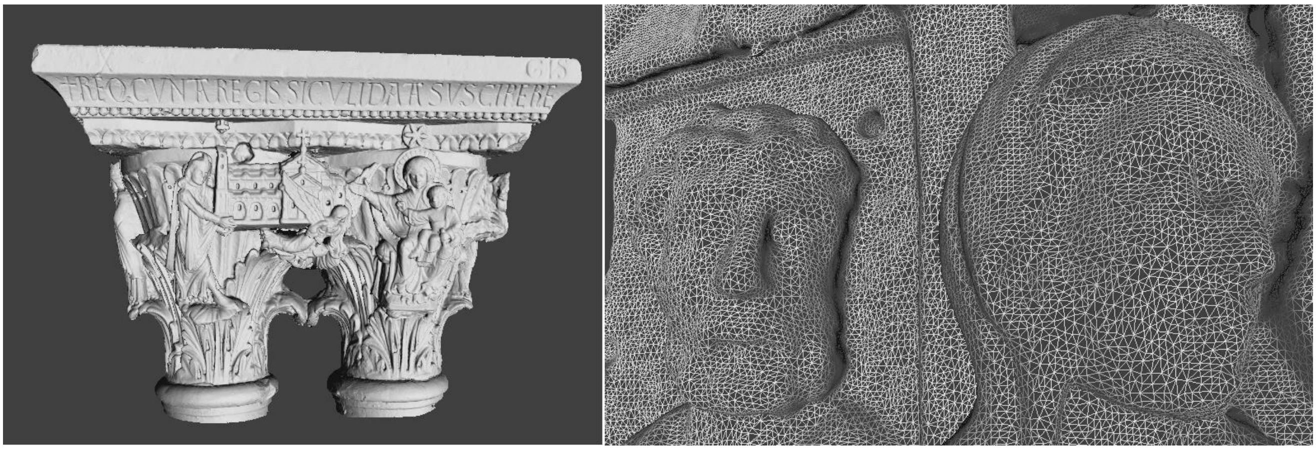

Figure 3: (a) Model of the “W8Sh82” (Dedication) capital; (b) Detail of “E1ShNE” capital.

Twenty highly detailed 3D models of the most artistically interesting capitals of the cloister have been reconstructed. The screenshot of a model is shown in Figure 3a. The number of triangles of each model ranges from 4.1 to 6 millions, depending on the shape complexity and size of each capital. We show in Figure 3b that even when a limited degree of mesh simplification has been performed, the details of the geometry are preserved and the capitals can be represented in a very realistic way.

Integrating color on 3D geometry: as previously mentioned, color mapping is an important step in the scanning pipeline. As a result of our acquisition campaign in Monreale we had high quality 2D and 3D information: the objective was to integrate them in a unique model, preserving the details of both color and geometry.
In order to produce a detailed colored model starting from the set of photos provide, two phases are necessary: alignment of each photo of the set on the model, using an appropriate tool [7], and assignment to each vertex of a color value, based on a weighted sum of the contributions of every photo which frames it.

Figure 4: The model of "E1ShNE" capital before and after color integration.

Following this approach, we produced a set of very detailed colored models: examples are shown in Figure 4. The union of 2D and 3D information can lead to a new way to archive and remotely represent Cultural Heritage objects.

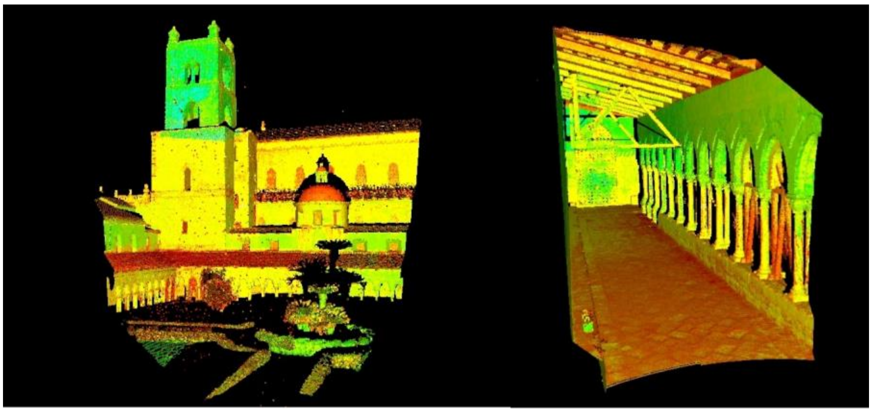

Figure 5: Examples of time-of-flight scans of the cloister.

Digitizing the cloister in 3D and as a panoramic image: the complete cloister has been also the focus of other digital acquisition actions. We planned to produce a 3D model of the entire cloister together with high-resolution panoramic images.
Panoramic images have been created by processing a set of digital photos (medium resolution, acquired with a consumer digital reflex camera) with the Stitcher tool by RealViz inc.
The entire cloister has been acquired with a Leica Geosystems HDS 2500 time-of-flight scanner. We show an example of the results of several scans depicting a portion of the cloister in Figure 5.

Figure 6: Visualization of a capital using Virtual Inspector.

4 EXPLORING THE CAPITALS OF THE CLOISTER

With the first phase of the CENOBIUM project we have just scratched the work we planned. Just 20% of the capitals have been acquired (even though they are the most significant, from an artistic point of view).

The main goal of the project is to make these data available to both experts and public. This will be implemented by using the image server DIGILIB developed by the Max Planck Institute for The History of Science and the ISTI-CNR VIRTUAL INSPECTOR tool (see Figure 6). The DIGILIB image server allows the remote visualization of high resolution image while the VIRTUAL INSPECTOR system provides a framework for the easy inspection and virtual manipulation of complex 3D models. This system allows also to add to the 3D surface a number of *hot spots* which could be used to link multimedia information to selected points of the surface (see the small red circles with an inscribed in Figure 6); by instantiating hot spots we can tell the story of the artefact or encode annotations on the mesh. The system inter-operates with a standard web browser, which supports the visualization of the MM content spatially indexed by the 3D mesh. *Virtual Inspector* has been recently extended to work also on the net, by adopting a remote rendering approach, and has been already used for a number of projects (e.g. [5]).

An important objective of the CENOBIUM project is the possibility for the users to compare in an integrated way all the multimedia information related to each capital. To do this the user can annotate object of interests (an image, a 3D model and so on) during the navigation and successively compare this multimedia object in an integrated framework currently under development.

Another goal of the CENOBIUM project is to contribute to the evolution of the VIRTUAL INSPECTOR system, since we plan to transform it from a static system (i.e. all the links should be defined statically) into a dynamic and cooperative system, where users will be allowed to add hot spots and the corresponding MM descriptions via an easy to use interface, following the “Wiki approach”. The details of this will be the subject of our future work.

5 CONCLUSIONS AND FUTURE WORK

We have presented the overall goals of the CENOBIUM project and the results produced in the first phase of the project, devoted to the acquisition of the digital models (2D and 3D) of the selected case study: the cloister of Monreale. Therefore, the work so far has been mostly technical: acquiring 2D/3D data and setting up the HTML and interactive framework needed to show them both locally (a kiosk installed in the Kunsthistorisches Institut) and on internet: the second phase, i.e. our future work, will focus on the development of the integrated framework for annotation and comparison and on the extension of the Virtual Inspector tool to make it a cooperative instrument.

ACKNOWLEDGEMENTS

The CENOBIUM project is dedicated to the memory of our colleague and friend Martina Hansmann. We would like to thank Leica Geosystems Italy for borrowing us a HDS2500 scanner.

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