Interactive visualization of artwork's 3D digital reconstruction

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Abstract

In this paper we describe the virtual reconstruction of a dismantled and dispersed piece of art: the Funerary Complex of Arrigo VII. To faithfully reconstruct the monument, all of the statues and elements of the mausoleum have been acquired in digital 3D format; then, with advanced computer graphics techniques, some of the accredited reconstructing hypothesis have been assembled and evaluated.

1. The case study

The Arrigo VII Mausoleum was one of the most famous funerary monuments of the XIV century, perceived as a model by contemporaries. It was carried out by Tino di Camaino, an artist who played a big role in the birth of modern sculpture in Europe. Unfortunately, this masterpiece was dismantled soon after its completion and we lack any written or graphic document of the original mausoleum.
A complex layout of the monument is indicated by the number, size, and iconography of the sculptures, making it quite different from other contemporary examples of funerary monuments. However, a 100% sure reconstruction of the original asset is almost impossible; many hypothesis have been formulated since the end of the XIX century , but none of them looks really convincing.

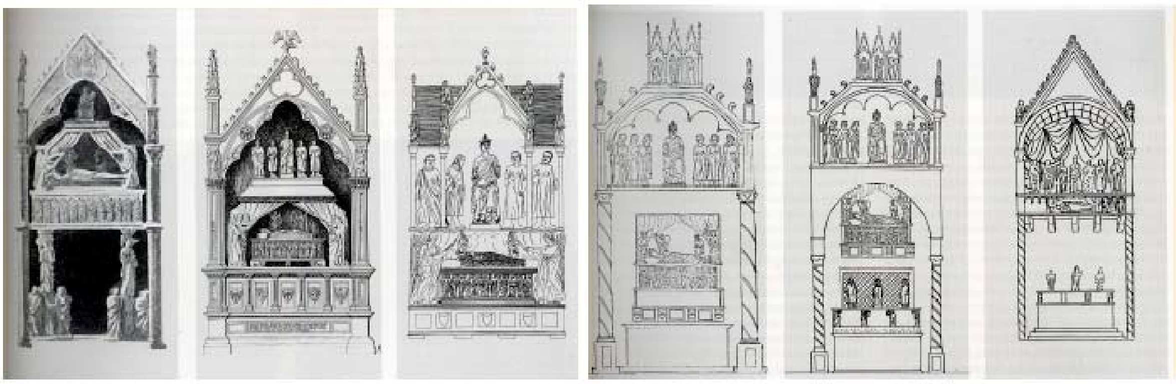

Fig. 1 – The different hypotesis on the original architecture of the mausoleum produced in previous studies.

Moreover quite recently, two scroll-bearing angels for centuries remained unacknowledged high up on the facade of the cathedral[1], have been recognized as part of the imperial tomb and new elements have been discovered inside the cathedral, in the inferior section of the apse: fragments of frescoes simulating a curtain with the emperors symbols (eagles and rampant lions) emerged after a restoration[2]. These facts reopened the debate over the original disposition of the monument.

2. Evaluation of recomposition hypotesis

The complexity of the problem induced art historian to look around for some help in their work and 3D graphics was perceived as the right tool for finding plausible solutions: the availability of 3D digital models of all the statues (high-fidelity digital copies which can also be easily manipulated and measured) and of the architecture would in fact help a lot in the evaluation of recomposition hypothesis, offering a realistic perception of reciprocal relations between the elements of the assembly and the interior space of the cathedral. So a team of technicians and art historian worked together to build up digital representations about the monument.

2.1 3D scanning of artwork

Scanning any 3D object requires the acquisition of many shots of the artefact taken from different viewpoints, to gather geometry information of the whole surface. Therefore, to perform a complete acquisition usually we have to sample many range maps; the number of range maps requested depends on the surface extent of the object and on its shape complexity.

Each statue has been sampled, in average, with 100-300 range maps (each one covering approximately a region 30x20 cm wide). For each statue, additional range maps were acquired from selected locations to reduce the extent of unsampled surface portions (approximately, 10-20% of the total number of range scans).This set of range maps has to be processed to convert it into a single, complete, non-redundant and optimal 3D representation. Processing of the scan set was performed with the ISTI-CNR scanning tools (MeshAlign, MeshMerge, MeshSimplify)[3], a suite of tools developed in the framework of the EU IST “ViHAP3D” project. In the case of the Arrigo VII project, the main problem was the size of the dataset to be processed (more than two thousand range maps).

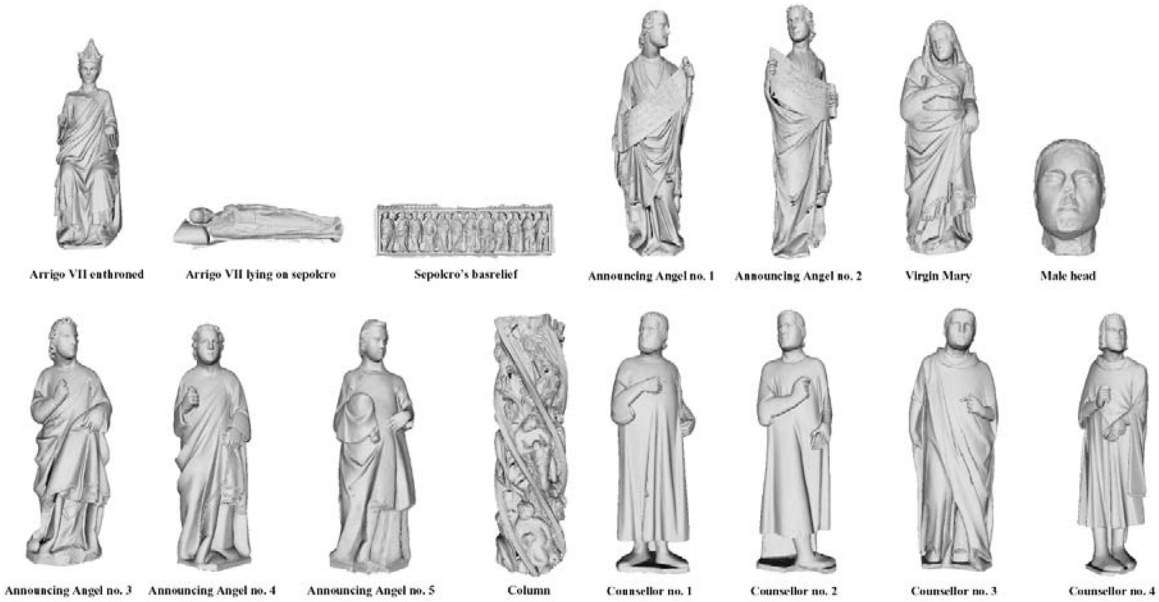

Fig. 2 – The set of artifact scanned; the images are not in scale

The number of range maps poses strong limitations on the use of commercial tools that are able to manage well just few tens of range maps. Since the scanning was performed in different times during a period of 1.5 years, it gave us also the possibility to evaluate on the field the quality improvement of our post-processing tools.

Also the architectural structure of the Pisa cathedral has been acquired with a scanning device, the lost component have been re-modelled with a CAD tool to reconstruct the XIV century situation of the apse.

2.2 Digital reconstruction

The two principal hypothesis for the mausoleum architecture, proposed by well known scholars[4,7] in the form of drawings, were verified in the 3D reconstructed apse. Thanks to the new technologies, we easily discovered that many details of these hypothesis were inconsistent both from a dimensional and a structural point of view. Therefore, we tried to devise new reconstruction hypothesis, and tested them with the help of our 3D tools which gave us the possibility to easily assess

the consistency of our attempts in terms of reciprocal proportion of the statues, of statues orientation, and of plausible extents of the mausoleum with respect to the apse[4].
At that moment only we tried to construct the original structure of the monument: along the process we also kept in mind two precious documentary evidences: the one attesting the original existence of an altar dedicated to St. Bartholomew located immediately under the tomb and the mention of a window in-between them, which we interpreted as referred to a section of the original central single light window, in its other parts evidently obliterated to consent the erection of the monument. Differently from previous attempts of reconstruction, we decided to accept only with great caution and not as safe examples, the disposal of the statues and the architectonic structure visible in other monuments, generally looked at as inspired by our tomb's structure (especially the Tarlati tomb in Arezzo); in any case, thanks to the versatility of the software and the disposability of the sculptures 3D models, we could always explore the consistency of our attempts, as for real dimension as well as reciprocal proportion of the statues among them and of them with the apse.

Fig. 3 – Virtual reconstruction of the hypothetical original architecture of the Arrigo VII monument in the Pisa cathedral apse

The most critical point of our work was of course the disposal of the sculptures, the ones convincingly recognized and unanimously accepted as part of the monument, inside a first draft of the architectonic structure. The 3D models of statues and architectonic fragments, previously acquired with submillimetric precision, have been imported in Virtual Inspector and located inside the hypothetical structure, immediately verifying the plausibility of both their reciprocal proportions and orientation.

3. Interactive visualization system

These digital models can also play an important role to let museum and Cathedral visitors better understand the monument. For this reason, we designed and implemented an interactive systems to locate the statues in their cultural and historical context and to present the models and the associated multimedia data both to ordinary public (museum visitors) and to experts (to support study and analysis of the complex).
The preliminary results of the project are presented to the public with a kiosk installed in the Museo dell'Opera del Duomo (Pisa, Italy), directly in the room where a subset of the Arrigo statues is exposed. The Arrigo VII visual presentation in the museum has been designed with introductory HTML pages, both to present some general artistic/historic information on the Arrigo VII complex, and to provide links to activate Virtual Inspector on the different statues. These introductory/index pages hold also links to time-navigation pages, which present for each sub-set of statues the different locations during their seven century lifespan (presented to the user through some pre-computed videos).

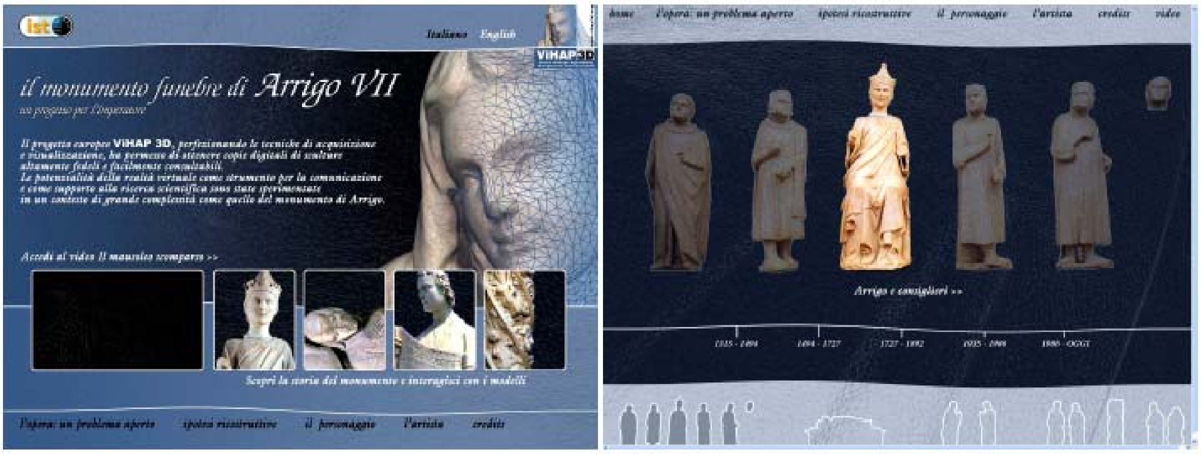

Fig. 4 – The initial screen of the multimedia kiosk and one of the following sub-index

3.1 Virtual inspector

Virtual Inspector is a new visualization system that allows naive users to inspect a large complex 3D model at interactive frame rates[8,6] on standard PC's. Virtual Inspector is mainly oriented to the visualization of single works of art (sculptures, pottery, architectures, etc.), and adopts a very intuitive approach to guide the virtual manipulation and inspection of the digital replica, based on a straightforward metaphor: we provide a *dummy* representation of the current inspected model on a side of the screen, which can be rotated on its axe; to select any given view the user has just to point with the mouse the corresponding point on the *dummy*. Virtual Inspector supports interactive modification of the lighting, to simulate in real time the "luce radente" (grazing light) effect that is usually used in real inspection to enhance the visualization of small-scale surface detail.

Fig. 5 – Virtual Inspector : the "Arrigo VII enthroned" statue rendered real-time with active hot-spot; a short popup panel with a short info appears when the mouse passes over the hot spot.

Other important characteristics of Virtual Inspector we want to emphasize here are its flexibility and configurability. All main parameters of the system can be easily specified via XML tags contained in a initialization file, such as: which are the 3D models to be rendered (a single mesh or multiple ones, as it is the case of the Arrigo VII complex), the system layout characteristics (i.e. how the different models will be presented on the screen), the rendering modes (e.g. standard Phong-shaded per-vertex colors or photorealistical BRDF rendering) and the interaction mode (e.g. model manipulation via the standard virtual trackball, the dummy-based "point and click" interaction, or both). The design of the Arrigo VII installation has been done with the help of a professional graphic designer. Consequently, the layout of the application, all icons and background graphics elements have been completely

redesigned with respect to previous incarnations of the Virtual Inspector system. This has been done by the easy specification of the new images and location on the screen of all icons and elements of the GUI in the XML initialization file and did not required neither programming nor recompilations of Virtual Inspector. It is a task that can be easily assigned to an operator with very limited IT competence.
Finally, while designing the Arrigo VII multimedia presentation we introduced support for hot-spots in Virtual Inspector. Hot spots are a very handy resource to associate multimedia data (e.g. html pages) to any point or region of a 3D model. This allows to design interactive presentations where the 3D model is also a natural visual index to historical/artistic information, presented using standard HTML format and browsers (see Figure 6).

Fig. 6 – Virtual Inspector : the “Arrigo VII enthroned” statue rendered real-time with active hot-spot; a short popup panel with a short info appears when the mouse passes over the hot spot.

The specification of hot spots is extremely easy in Virtual Inspector; modifications to the 3D models are not required. We provide a simple 3D browser to the person in charge of the implementation of the multimedia presentation, which allows to query the 3D coordinates of any point on the surface of the artifact (by simply clicking with the mouse on the corresponding point). Then, a new hot spot is specified by introducing a new XML tag in the Virtual Inspector specification file. The hot spot XML tag specifies basically the 3D location and the action that has to be triggered when clicking on the hot spot (e.g. the name of the html file, if we want to open a multimedia page). After activation, the control passes to the html browser, while Virtual Inspector remains sleeping in the background and regains automatically the control of the interaction whenever the html browser is closed.

Acknowledgements

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